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ABSTRACT

This guide provides basic information regarding the utilization and application of pesticides. Classifications are given for herbicides, insecticides, fungicides, and fumigants with indications of how each works. Types of application and appropriate equipment are discussed. Safety to both the applicator and the environment are stressed. A glossary of terms used in pest control is included for reference. (CS)

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ORNAMENTAL AND TURFGRASS PEST CONTROL

SE 024 332

COUNCIL FOR ENVIRONMENTAL STUDIES . COOPERATIVE EXTENSION SERVICE
COLLEGE OF AGRICULTURE . UNIVERSITY OF ARIZONA . TUCSON, ARIZONA

ORNAMENTAL AND TURFGRASS PEST CONTROL

COUNCIL FOR ENVIRONMENTAL STUDIES

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TUCSON, ARIZONA 85721

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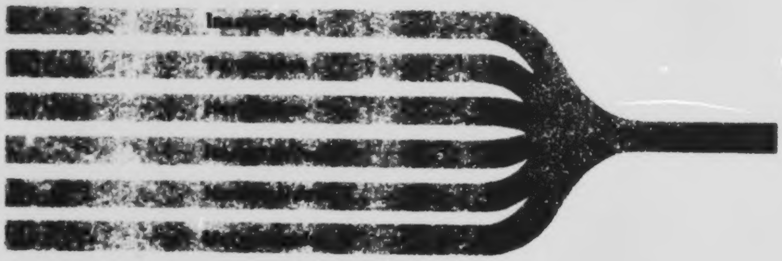
Here are the types and uses of pesticides:



Insecticide: controls insects and other related pests such as ticks and spiders.

Miticide: controls mites.

Acaricide: controls mites, ticks and spiders.

Nematicide: controls nematodes.

Fungicide: controls fungi.

Bactericide: controls bacteria.

Herbicide: controls weeds.

Rodenticide: controls rodents.

Avicide: controls birds.

Piscicide: controls fish.

Molluscicide: controls mollusks, such as slugs and snails.

Predacide: controls pest animals.

Repellent: keeps pests away.

Attractant: lures pests.

Plant Growth Regulator: stops, speeds up, or otherwise changes normal plant processes.

Desiccants and Defoliants: harvest-aid chemicals used to remove or kill leaves and stems.

Antitranspirant: reduces water loss from plants.

HOW PESTICIDES WORK

Pesticides can be grouped according to what they do. Many work in more than one way. Read the label to find out what the one you are using will do.

Some of the ways pesticides work are:

Contacts: kill pests simply by contacting them.

Stomach poisons: kill when swallowed.

Systemics: kill pests by being taken into the blood of the animal or sap of the plant upon which the pest is feeding.

Translocated herbicides: kill plants by being absorbed by leaves, stems, or roots and moving throughout the plant.

Fumigants: gases which kill when they are inhaled or otherwise absorbed by the pest.

Selective: kills certain kinds of plants or animals.

Nonselective: kills most plants or animals.

USING PESTICIDES

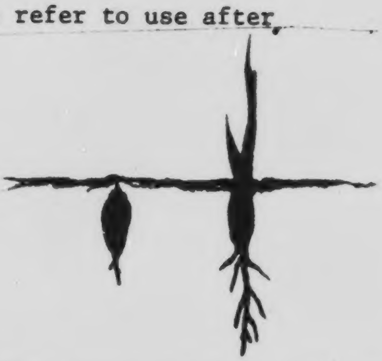
Many terms describe when and how to use pesticides.

When To Use

Preemergence: used before crops or weeds emerge. May also refer to use after crops emerge or are established, but before weeds emerge.

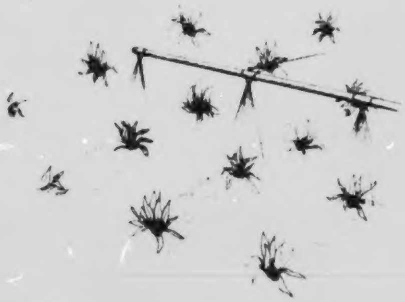
Preplant: used before the crop is planted.

Postemergence: used after the crop or weeds have emerged.



Preemergence and Postemergence

How To Use

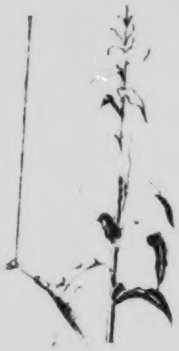


Band

Band: application to a strip over or along each crop row.

Broadcast: uniform application to an entire, specific area.

Dip: complete or partial immersion of a plant, animal, or object in a pesticide.



Directed

Directed: aiming the pesticide at a portion of a plant, animal, or structure.

Drench: saturating the soil with a pesticide; oral treatment of an animal with a liquid pesticide.

Foliar: application to the leaves of plants.

In-furrow: application to or in the furrow in which a plant is planted.

Over-the-top: application over the top of the growing crop.

Pour-on: pouring the pesticide along the midline of the back of livestock.

Sidedress: application along the side of a crop row.

Soil incorporation: application to the soil followed by use of tillage implements to mix the pesticide with the soil.

Spot treatment: application to a small area.

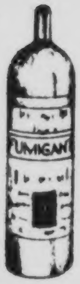
PESTICIDES

PESTICIDE FORMULATIONS

Pesticides are usually not used in their pure form. The active ingredient is usually mixed with inert substances. This mixture is called a pesticide formulation.

A pesticide formulation should be prepared so the user can apply it in a safe, convenient and effective manner with available or easily modified application equipment.

Some of the pesticide formulations available are listed on the following pages.



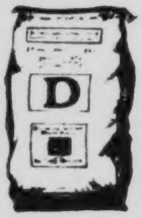
Liquified Gases

Some fumigants are gases which become liquid when placed under pressure. This type of formulation is stored under pressure. The pressure may be either high or low, depending on the product. Some nematicides, insecticides, fungicides, and rodenticides are formulated this way. These formulations are applied by:

- injecting them directly into the soil,
- releasing them under tarps, or
- releasing them into a structure such as a grain storage elevator.

Some other active ingredients remain liquid in an ordinary container, but turn into a gas or vapor as or after they are applied. These formulations do not require storage under pressure. They must be put into the soil or confined in a space before they turn to gas. Otherwise, they could be lost into the air.

Dry Formulations



Dusts (D)

Most dust formulations are ready to use and contain:

- an active ingredient, plus
- a very fine or powdered dry inert substance such as talc, clay, nut hulls, or volcanic ash.

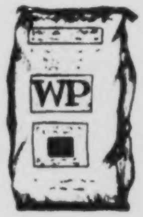
The amount of active ingredient usually ranges from 1 to 10 percent.

All the ingredients are ground into fine, uniform particles. Inert ingredients are often added so the formulation will store and handle well. Some active ingredients are prepared as dusts because they are safer for crops in that form. Dusts always must be used dry. They can easily drift into non-target areas. You can get dusts for use on seeds, plants, and animals.

Dust concentrates are available for further dilution with dry inert ingredients before they are ready to use.

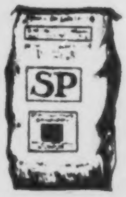
Granules (G)

Granular formulations are dry. Most are made by applying a liquid formulation of the active ingredient to coarse particles (granules) of some porous material. Often used are clay, corn cobs, or walnut shells. Granule particles are much larger than dust particles. The pesticide is absorbed into the granule, or coats the outside of it, or both. Inert ingredients may be added to make the formulation handle well. The amount of active ingredient ranges from 2 to 40 percent. Granular formulations are safer to apply than EC's or dusts. They are most often used as soil treatments. They may be applied either directly to the soil or over plants. They do not cling to plant foliage, but they may be trapped in the whorls of some plants. Granular formulations, like dusts, should always be used dry. Never mix them with water.



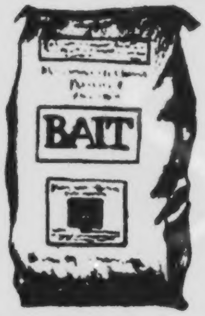
Wettable Powders (WP or W)

These are dry, finely ground pesticide formulations. They look like dusts. But, unlike dusts, they are made to mix with water. Most wettable powders are much more concentrated than dusts. They contain 15 to 95 percent active ingredient—usually 50 percent or more. Wettable powders form a suspension rather than a true solution when added to water. Good agitation is needed in the spray tank to maintain the suspension. Good wettable powders spray well and do not clog nozzles. They are abrasive to pumps and nozzles. Most wettable powders are safer for use on plants than EC's are.



Soluble Powders (SP)

Soluble powders also are dry formulations. But when they are added to water, they form true solutions. Agitation in the spray tank may be needed to get them to dissolve. After that, no more agitation usually is needed. The amount of active ingredient in an SP is usually above 50 percent.



Baits (B)

A bait formulation is an edible or attractive substance mixed with a pesticide. The bait attracts pests and the pesticide kills them when they eat the formulation. Baits usually are used to control rodents and insect pests. They can be used in buildings or outdoors. The amount of active ingredient in most bait formulations is quite low, usually less than 5 percent.

Liquid Formulations

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate can be mixed with water to form an emulsion. Each gallon of an EC usually contains 2 to 8 pounds of active ingredient. Diluted EC's usually need little agitation in the spray tank.

EC's can damage some crops. These crops may require a different formulation of the active ingredient such as a wettable powder or a dust.

Solutions (S)

High Concentrates—These are special formulations. They usually contain 8 or more pounds of active ingredient per gallon. They may contain only the active ingredient itself. Most are designed to be used as is or diluted with oil or petroleum solvents. They contain chemicals that allow them to spread and stick well. Ultra low volume (ULV) concentrate materials should be used without further dilution.

Low Concentrates—These formulations usually contain less than 2 pounds of active ingredient per gallon. Most of them are solutions in highly refined oils. They need no further dilution. The label will give you directions for use. They are often used for:

- controlling household and industrial pests,
- mothproofing.
- livestock sprays, or
- space sprays in barns.

Flowables (F or L)

Some active ingredients can be made only as a solid, or at best, a semisolid. These are finely ground and put into a liquid along with other substances that make the mixture form a suspension. They are *flowable solids*. Flowables can be mixed with water. They seldom clog spray nozzles. They need only moderate agitation. Most of them handle as well as EC formulations.

Aerosols(A)

These pesticide formulations are liquids that contain the active ingredient in solution in a solvent. More than one pesticide may be in these formulations. Most aerosol formulations have a low percentage of active ingredient. They are made for use only in fog- or mist-generating machines. They are used in structures, greenhouses, and barns for insect control.

Formulation Symbols

A - Aerosol
B - Bait
D - Dust
E or EC - Emulsifiable Concentrate
F or L - Flowable
G - Granule
S - Solution
SP - Soluble Powder
WP - Wettable Powder

ADJUVANTS (ADDITIVES)

An adjuvant is a material which is added to a formulation to improve its physical or chemical characteristics. Adjuvants are most commonly used to aid in the performance of the pesticide including a more satisfactory spread and "weathering" of the deposit when it is applied. Adjuvants include spreaders, wetting agents, stickers and safeners.

Functions of Adjuvants

1. Wet the pest or foliage
2. Decrease or increase rate of evaporation
3. Help weatherproof the pesticide
4. Aid penetration and translocation
5. Adjust pH, prolong spray life
6. Improve uniformity of deposit
7. Improve compatibility of mixtures
8. Increase safety to crops
9. Reduce drift hazard

Pesticide Compatibility

When two or more pesticides can be safely mixed together, or used at the same time, they are compatible. When they cannot be mixed or used together, or used at the same time, they are said to be incompatible. Some pesticides are incompatible because chemically they will not mix. Some pesticides will mix together well but the results are not the same as when they are used alone. For example, one pesticide may require soil incorporation while the other pesticide needs to be applied to the soil surface. Incompatible pesticides may, when mixed, combine chemically and form another compound.

Compatibility Charts

There are two pesticide compatibility charts (Spray Compatibility Chart and Herbicide Compatibility Chart) available from:

Meister Publishing Company
37841 Euclid Avenue
Willoughby, Ohio 44094

Before you mix pesticides, or a pesticide and another material such as fertilizer, you should know that once mixed you will get the best benefit from both. One reason for combining pesticides is to save time. However, if the two materials are incompatible you may lose time. Besides time, you may also lose the chemical (which is costly), or you may get poor results or injure the turf.

The pesticide label will sometimes indicate incompatibility problems. Some pesticide formulations are prepared for mixing with other materials and are registered for pre-mixes or for tank mixes. If this is true, it will be so indicated on the label. Make sure materials are compatible and cleared for the combination before mixing or using them together.

Pesticide Residues

Modern analytical methods make it possible to detect very small amounts of pesticides in plant or animal products. Quantities as small as one part per million (ppm) and even one part per billion (ppb) can be detected on plants. One part per million(ppm) is one pound in 500 tons, or one ounce in 31½ tons, or one ounce in 63,000 pounds.

What is a Residue?

A residue is the amount of the pesticide or the chemical that the pesticide turns into that can be found on, or in, a plant, animal or soil to which the pesticide has been applied. Residues can come from pesticides that you apply on a neighboring area (by drift) or pesticide uptake from the soil of pesticides applied previously.

Some pesticides like DDT, aldrin and dieldrin are highly persistent and last for long periods of time, even years. Some pesticides are not persistent and last only a few days. Naturally, the persistent pesticides are more likely to cause long-lasting residues.

The pesticide applicator must do everything he can to eliminate residue problems.

Examples of Pesticide Persistence

Herbicide Persistence in Soil	
dalapon (Dowpon)	10-60 days
dicamba (Banvel)	3-6 months
diquat	none
paraquat	none
benefin (Balan)	4-5 months
DSMA	none
dichlobenil (Cascron)	2-6 months
DCPA (Dacthal)	2-6 months
siduron (Tupersan)	3-6 months
2,4-D	1-3 weeks
2,4,5,-T	2-5 weeks
silvex	2-5 weeks

Insecticide Persistence in Environment	
carbaryl (Sevin)	7-10 days
chlordane	2-4 weeks (yrs in soil)
diazinon	2-4 weeks (2 mos in soil)
chlorpyrifos (Dursban)	10-14 days
fensulfothion (Dasanit)	4-6 weeks
malathion	5-10 days
parathion	3-7 days
arsenates	years in soil

HERBICIDES

How Herbicides Kill Plants

Growth Regulators

The plant growth regulator type herbicides are thought to interfere with enzyme function or upset the balance of natural growth-regulatory chemicals and thereby disrupt the entire plant growth process, leading to eventual death.

Inhibitors of Photosynthesis

Photosynthesis is the process by which radiant energy is converted to chemical energy in the plant. Herbicides which interfere with photosynthesis cause eventual starvation of the plant by not allowing the radiant-to-chemical energy conversion in the plant. Plants which are killed by photosynthetic inhibitors will germinate and may emerge but will die shortly thereafter. Triazines and ureas inhibit photosynthesis.

Inhibitors of Cell Growth

Cell division and elongation are the first growth processes to occur in a germinating seed. Certain herbicides such as carbamates, anilines, and dinitroanilines are thought to interfere with cell growth. Plants killed by these herbicides will germinate but usually die before emergence.

Desiccants

Certain herbicides such as dinitro and paraquat kill plants very rapidly. Dinitro causes the protein portion of the cell membrane to collapse, leading to rapid death. Paraquat causes the buildup of a toxic molecule in plants carrying on photosynthesis, resulting in complete cell destruction.

Factors Affecting Herbicide Activity and Rates of Application Environmental Factors

Rainfall

Rain during or closely following a foliar post emergence application may wash the herbicide from leaves and reduce its effectiveness. Traces of rain, dew or precipitation from fog a few hours after spraying could increase penetration and effectiveness by remoistening herbicidal deposits.

Rainfall is essential for satisfactory weed control from most pre-emergence herbicides. Rain moves the chemical into the top ½-inch layer of soil where most of the weed seeds germinate. The amount of rainfall required varies with the chemical used. For most herbicides, ½-inch of rain or more is required for maximum effectiveness. A delay in rainfall of more than a few days following application usually reduces the degree of weed control. Heavy rainfall (several inches or more) soon after a pre-emergence application can be detrimental. It may carry the chemical to the depth of the seed or below.

Humidity

In general, a high relative humidity at and after spraying is likely to increase herbicidal penetration, absorption and, presumably, the killing of the weed. This is because under high humidity stomates (pores) on the leaves are open, allowing more herbicide to enter, and cuticle (wax) of the leaf surface is softer. High humidity also prolongs the "drying time" of the herbicide spray on the foliage.

Temperature

Post-emergence weed control is best when temperatures before spraying have favored uniform weed seed germination and rapid growth. At the time of spraying, high temperatures generally increase the activity of herbicides. For example, the toxicity of DSMA to plants is greatly modified by temperature. When the temperature is below 65°F, the toxicity of DSMA is reduced so that an increase in application rate is recommended. When the temperature rises above 85°F, application rates must be reduced to prevent serious injury to turf.

With some herbicides such as dichlobenil (Casoron), the volatility of the chemical limits surface application when temperatures are warm.

Temperatures have important effects on the dissipation or loss of herbicides from plant foliage or from soil. Chemicals such as EPTC and some esters of 2,4-D rapidly evaporate. When these herbicides are applied to plants or the soil, their loss as vapors is quite rapid at high temperatures, which can reduce their killing action. In soil treatments, vapor losses are decreased by incorporation.

Light

Some herbicides are degraded by sunlight by a process called photodecomposition. Thus, if herbicides can be photodecomposed, it is beneficial to incorporate them into the soil rather than applying them on the soil surface.

Other Factors

Plant Species and Varieties

In general, it is more difficult to control perennials than annuals. The rates may need to be increased one or two-fold to kill perennials and sometimes the increased rates are not effective. Also repeat applications may be necessary to effectively control certain weed species. The perennial weeds are difficult to control with herbicides because they usually have a deep tap root,rhizome, tubers or some other underground storage tissue. In order to control perennials the herbicide must be translocated through the plant and down into the underground food storage tissue.

This explains why contact herbicides are not effective against such perennials. The foliar portion of the plants is killed but the food reserves provide energy for new growth within a short period of time for this reason, repeat applications if the herbicides are often used.

Surface Active Agents (Surfactants)

These materials include wetting agents, emulsifiers, detergents, spreaders, sticking agents, and dispersing agents. Surfactants recommended to be added to herbicides are usually of the non-ionic type. (Check label to see what type surfactant is recommended.) Generally, surfactants make herbicides more effective when applied to plant foliage. This is because they may:

--increase wetting and spreading of the spray
--keep spray from washing off
--soften cuticle (wax) on leaves to allow more herbicide to enter
--have a toxic effect on the plant itself

In fact, surfactants sometimes increase the activity of herbicides so much that they become less selective and injure crops. Too much surfactant, especially when high spray volumes are used, can also cause the herbicide droplets to "run off" the foliage resulting in reduced effectiveness of the herbicide.

Soil Factors Affecting Herbicides
Factors Affecting Activity and Rates

Organic Matter

Organic matter in soils reacts with and absorbs many applied herbicides. Generally the higher the organic matter content, the higher the herbicide rate required for effective weed control. (This has more effect on pre-emergence materials than post-emergence foliar applications of 2,4-D, etc.)

Clay Content

Fine textured soils (clays and silts) provide more surface area for adsorption of herbicides than coarse soils (sands and gravels). Higher herbicide rates are generally needed on finer textured soil -- especially soils containing a large percentage of clay. Also, the higher C.E.C. (cation exchange capacity), which varies with the type of clay, can affect this adsorptive characteristic.

Soil pH

Extremely acid soils (pH of less than 5) generally necessitate higher rates of herbicides than soils in the pH range of 5 to 7.

Soil Temperature

At optimum (best) soil temperatures for plant growth, herbicides are usually more active due to faster uptake and translocation of the herbicide by the actively growing plant. On the other hand, microbes (bacteria, etc.) grow best in warm, moist soil and decompose the herbicide at a faster rate.

With the higher soil temperatures, the volatile herbicides are more active but if temperatures are consistently high, these herbicides may escape from the soil too fast to give the best weed control.

Soil Moisture

Soil moisture affects plant growth, herbicide breakdown and volatilization in the soil. Highest herbicidal activity normally occurs under optimum soil moisture conditions. Volatilization is greater under wet than under dry conditions because water has occupied the adsorption sites on the soil particles. Water evaporating from a soil surface may transport and concentrate a chemical at the soil surface.

Factors Affecting Persistence

All the factors described above also influence the length of time a herbicide lasts (persists) in the soil. It is important that a herbicide persist long enough to give good weed control but then decompose with a minimum effect on the environment.

Microorganism Decomposition

A warm, moist, well aerated, fertile soil is most favorable to microbes and to the breakdown of most herbicides. The main microbes in the soil like algae, fungi and bacteria may be adversely affected by normal rates of herbicides, but their population usually returns to normal with the disappearence of the pesticide.

Chemical Decomposition

Chemical processes generally break down and decompose herbicides to inactive forms.

Adsorption by Soil Particles

Soil particles, especially clay and organic particles, have a marked influence on the behavior of soil-applied herbicides. For example, the negative charge of clay particles ties up positive ions of many herbicides, thus increasing the persistence of the chemical but at the same time, in extreme cases, making it unavailable to kill the weeds or harm the grass plant.

Movement or Leaching through the Soil

If leaching is too fast, the activity and persistence of the herbicide is decreased. Leaching is sometimes helpful with low water-soluble compounds because it moves the chemical from the soil surface into the weed seed zone. Leaching may also contribute to the movement of pesticides into the ground water in which it can be carried to the other locations as an undesirable contaminent. In this respect, adsorption, microbial decomposition, chemical reaction and absorption by plants are very important in ridding the environment of pesticide residues after desirable effects of pesticide use have occurred.

Classification of Herbicides

I Aliphatic Acids

- A. Example

    dalapon

- B. Characteristics

    organic
    systemic
    residual
    non-selective

II Arsenicals

- A. Organic
    - 1. Examples

        Cacodylic Acid
        DSMA
        MSMA

    - 2. Characteristics

        systemic
        non-residual
        selective

- B. Inorganic
    - 1. Examples

        calcium arsenate

    - 2. Characteristics

        contact
        residual
        selective or non-selective

III Benzoic Acids

- A. Example

    Dicamba

- B. Characteristics

    organic
    systemic
    residual
    selective

IV Heterocyclic Nitrogen Compounds

- A. Trizines
    - 1. Examples

        simazine

    - 2. Characteristics

        organic
        systemic
        residual
        selective

- B. Others
    - 1. Example

        amitrole

    - 2. Characteristics

        organic
        systemic
        residual
        non-selective

Classification of Herbicides (cont'd)

V Phenoxy Compounds

A. Examples

2,4-D
silvex
mecoprop

B. Characteristics

organic
systemic
short-residual
selective

VI Phthalic Acids

A. Example

DCPA (Dacthal)

B. Characteristics

organic
contact
residual
selective

VII Dinitroanilines

A. Examples

Benefin
Trifluralin

VIII Nitriles

A. Examples

Bromoxynil
Dichlobenil

INSECTICIDES

How Insecticides Kill Insects

Insecticides can be classified by the way they exert their action on the pest. One system of classification is as follows:

Systemic - an insecticide like phorate (Thimet) or demeton (Systox) which, when applied to a plant or animal, moves within the plant or animal to a location where it kills insects by contact or stomach poisoning.

Contact - an insecticide like carbaryl (Sevin), malathion, parathion, aldrin and nicotine which, when applied to a surface, a leaf or an animal, is in position to kill any insect which comes in contact with that surface. Insecticides that kill by contact do not have to be eaten by the insect to be effective.

Stomach Poison - an insecticide such as carbaryl (Sevin), malathion, lead arsenate and aldrin applied to a plant or animal which will kill the insect pest when a portion of the insecticide is eaten by the insect.

Fumigant - an insecticide in the form of a gas, vapor, fume or smoke that will kill insects on contact.

Bait - a formulation of a pesticide and an attracting substance.

Soil Insecticide - a term usually applied to those chemicals having characteristics which make them particularly useful in controlling soil-living insects. Examples include chlordane, aldrin and diazinon.

Many of the modern insecticides possess more than one of the characteristics of the above classifications. For example, demeton (Systox) can act as a systemic, contact or stomach poison.

Chemical Nature of Insecticides

All insecticides can be placed in a chemical class based on their chemical composition. These generally recognized classes are as follows:

Organophosphorous - These compounds are synthetic organic chemicals containing carbon and phosphorus. Many are highly hazardous such as parathion, while others are only slightly hazardous, such as malathion. In general these chemicals persist only a short time.

Organochlorine - These compounds, also called chlorinated hydrocarbons, are synthetic organic chemicals containing carbon and chlorine. Generally, these compounds are not as acutely hazardous to man as the organophosphate compounds but most are more likely to persist in nature for relatively longer periods of time because they do not break down readily. Examples of these compounds are DDT, aldrin, dieldrin, heptachlor, mirex and toxaphene.

Carbamate - These compounds are synthetic esters of carbamic acid. Some are highly toxic like aldicarb (Temik) and carbofuran (Furadan), while others like carbaryl (Sevin) are only slightly toxic. In general these chemicals persist only a short time. The mode of action of carbamates is that of inhibiting cholinesterase.

Botanicals - These are insecticidal chemicals produced by and extracted from plants. They include some highly toxic chemicals like strychnine and nicotine, and some relatively safe compounds like pyrethrin and rotenone.

Inorganic - These insecticides are usually salts of heavy metals like arsenic and lead. Some are highly toxic, irreversible poisons, while others are relatively safe.

Others - The rest of the insecticides fall into one of a number of groups. They include petroleum oils, carbonates, etc.

Toxicity and Hazard of Insecticides

The term toxicity is used to describe the potential killing power of a pesticide. Hazard, on the other hand, refers to the danger or risk of being injured or poisoned while using the chemical. The warning statement on the label refers to the toxicity class; those products with a low LD_{50} value are very toxic, and those with higher values less toxic.

Some insecticides, such as parathion, are extremely toxic, but when handled by a competent professional applicator, are not very hazardous. Having a low toxicity rating, however, does not assure that a product is not hazardous. One example would be any readily available household insecticide. This product can be bought in any supermarket, without the purchaser having to show any knowledge of proper use or safeguards. Since it is so easy to purchase, many people have the mental attitude that this product is not dangerous. Because it is not handled with care or stored properly, this pesticide (even though it may be within the least toxic class) may be extremely hazardous. Such readily available household products account for the majority of poisonings of young children.

Resistance of Insects to Insecticides

Each time we use an insecticide, we automatically select and kill those insects most susceptible to that insecticide. Rarely does an insecticide kill all of the target pest population. Some insects excape death by simply avoiding the chemicals; such morphological features may include hairs or thick cuticles, which prevent the chemicals from contacting and entering the insect's body.

Others, by the nature of their physiology are able to withstand direct contact with the pesticide. An insect may produce an enzyme which quickly breaks down the insecticide and renders it ineffective. This may also result in cross-resistance, in which an insect has the ability to resist chemicals with similar modes of action. An example would be an insect being resistant to malathion, an organophosphate which has as its mode of action the ability to interfere with the insect's nervous system. This same pest may also be resistant to carbaryl, a carbamate, which has a similar mode of action to malathion.

When we repeatedly use the same pesticide, this simply aids in further selection; a "resistant" population then develops. When this resistance can be passed on to the offspring, the whole population becomes resistant. In many insects such as mosquitoes, house flies, rootworms and wireworms the degree of resistance has increased in the surviving population to the point that continued use of certain pesticides has become totally ineffective.

CLASSIFICATION OF INSECTICIDES

I. Arsenics

A. Example

lead arsenate
calicium arsenate

B. Characteristics

inorganic
residual
selective
stomach poisons

II. Carbamates

A. Example

carbaryl (Sevin)

B. Characteristics

organic
contact
non-residual
non-selective

III. Chlorinated Hydrocarbons

A. Examples

DDT
chlordane
aldrin
dieldrin
methoxychlor (non-residual)

B. Characteristics

organic
contact
residual
selective

IV. Organophosphates

A. Examples

malathion
parathion
Di-syston
diazinon

B. Characteristics

organic
non-residual
systemic and non-systemic
selective and non-selective

FUNGICIDES

How Fungicides Work

Certain chemicals can protect plants from disease-causing pathogens and should be used for disease control only after giving careful consideration to other control practices available and their relative costs and effectiveness. It is important to stay up-to-date since new chemicals or techniques can save you money and unnecessary hardship. Also the approved and legal practices which may be employed may change quickly and drastically.

Disease control chemicals are applied to seed, soil and foliage (leaves and stems). They are applied to protect plants by preventing the beginning of disease development. It is hard to control a plant disease once it is established in a plant. Protective fungicides form a barrier to keep pathogens from infecting plants. Some chemicals are taken up by the roots or may enter the leaves and stems. Once they are inside the plant, they may move from cell to cell and be distributed with the sap in the plant's vascular system. Such chemicals are said to be "systemic". At this time only a few fungicides and nematicides are known to be systemic.

Chemicals must be formulated for disease control application. Disease control materials are formulated as liquids, emulsifiable concentrates, wettable powders, dusts and granules. Also, certain formulations are available for "low volume" spraying. All of these formulations may be used for soil or foliage applications except for the granular formulation which is applied to soil.

Pesticide solutions for disease control may be applied to the foliage or soil. They are all mixed or suspended in water and then sprayed on the plants. Manufacturers generally use a high percentage of active ingredient (50-85%). Dusts may also be applied to foliage or soil; however, they are formulated with a very low percentage of active ingredient (1-5%). Water may act as a carrier to spread liquid formulations over the plant or soil surfaces whereas air, talc, powdered corn cobs, etc. act as carriers for dust particles. Dusts require special equipment for application, tend to be wastful and more hazardous, and are being used less and less.

Granular formulations are satisfactory for soil applications in disease control and contain from 10-65% active ingredient. The active ingredient is coated over inert particles, such as calcined clay particles, and may be overcoated with a water-soluble layer of an inert chemical to make the formulation safer for the applicator to handle. The overcoating may control the rate at which the active chemical dissolves in the soil water, thus making it more effective. Some granular formulations may consist of combinations of pesticides and fertilizers. One advantage of granular formulations is that they may be applied with some of the equipment used to apply granular fertilizers. Granulars have been found to be especially effective for treatment during freezing weather.

Classification of Fungicides

I Contact Fungicides

- A. Antibiotics
  - 1. Example
    - cycloheximide (Acti-dione)
  - 2. Characteristics
    - organic
    - non-residual
    - selective
- B. Aromatic Compounds
  - 1. Example
    - PCNB (Terraclor)
  - 2. Characteristics
    - organic
    - residual
    - selective
- C. Heterocyclic Nitrogen Compounds
  - 1. Examples
    - analizine (Dyrene)
    - captan
    - chlorothalonil (Daconil 2728)
  - 2. Characteristics
    - organic
    - non-residual
    - selective
- D. Mercuries
  - 1. Examples
    - organic (PMA)
    - inorganic (Calo-clor, Calo-gran)
  - 2. Characteristics
    - residual
    - selective
- E. Organo-sulfur Compounds
  - 1. Examples
    - thiram (Tersan 75)
    - dithiocarbamates (Ferbam, Ziram)
    - ethylenebisdithiocarbamates (zineb, maneb, zinc-iron-maneb Comples--Tersan LSR and Fore)
  - 2. Characteristics
    - organic
    - non-residual
    - selective

II. Systemic Fungicides

- A. Benzimidazoles
  - 1. Examples
    - benomyl (Tersan 1991)
    - thiabendazole (Mertect 140)
  - 2. Characteristics
    - organic
    - residual
    - selective
- B. Thiophanates
  - 1. Examples
    - methyl (Fungo and Spot Kleen)
    - ethyl (Cleary's 3336)
  - 2. Characteristics
    - organic
    - residual
    - selective
- C. Chloroneb
  - 1. Example
    - Tersan SP

C. Chloroneb (cont'd)

2. Characteristics

organic
residual
selective

D. Pyrimidines

1. Example

triarimol

2. Characteristics

organic
residual
selective

FUMIGANTS

How Fumigants Work

All fumigant pesticides are applied as gases or have a gaseous phase after they are applied. Pests absorb the poisonous fumes and are killed. Depending on the fumigant, their formulation, methods of application are as follows:

Gases (under covers) - At higher temperatures fumigants such as methyl bromide and chloropicrin become gases immediately after they are released. If they are released in the open, they persist only a very short time. In the container they are liquids only because they are under pressure. In order for these fumigants to work properly, their fumes must be confined under a gas-proof tarp or in an air tight enclosure.

Liquids - Fumigants, such as D-D (nemafene) and Vapam that are injected into the soil without using covers, are liquids (not under pressure) in their containers. When they are released, they do not immediately become a gas like methyl bromide. In the soil they slowly volatilize. These materials are often used without being covered with a gas-proof trap. However, a seal such as water or soil or both is necessary to contain the gas.

Solids - Some liquid fumigants such as DBCP (Nemagon) can be formulated and applied as solid granules. These fumigants have an even lower vapor pressure than D-D. When these solid granules are applied to the soil, the gaseous ingredients escape into the soil and kill the pests.

Gels - Gels are recent formulation developments that permit the application of high-vapor-pressure fumigants like methyl bromide without using a tarp (cover). These jelly-like substances tie up and hold fumigants and release them slowly into the soil.

Factors Affecting Fumigant Performance

The following factors greatly influence the performance of a fumigant:

Temperature

Fumigants, once they are applied, must become gases to be effective. If the temperature is high, the conversion (change) to a gas is rapid and if it is low, the conversion is slow. However, if the temperature is too high or too low, the change may be too rapid or too slow to give proper control. Check the label to determine the proper temperature range for applying a particular fumigant (50-80°F for most fumigants).

Moisture

Fumigants that are applied to the soil or to fumigate seed are affected by the soil or grain moisture. Fumigants applied in soil with a moisture content that is too high or too low may not give good pest control. In wet soils, the water occupies most of the air space so the fumigant moves very slowly. Soil fumigants perform best under average soil moisture conditions even though some move in the liquid phase.

Soil Condition and Type

If other factors are equal (like temperature and moisture), fumigants will move faster in loose and sandy soils than in clay or compact soils. Fumigants applied to a cloddy or poorly prepared soil are likely to give poor pest control. High organic soils and soils with plant residues (stalks, vines, etc. may "tie up" the fumigant. Fumigant rates may have to be increased in such soils. Proper planning and soil preparation can reduce this problem.

Timing and Aeration

Proper timing is important in applying most fumigants. For example, with seedbeds the temperature is usually higher and fumigants perform better in the fall than in the spring. The proper lapse time from application to planting is essential with fumigants. The exposure time varies with the fumigant applied, temperature, soil type, and other factors.

Aeration time, or the time required to allow the fumigant to leave the soil, is important to avoid plant injury.

Classification of Fumigants

I. Characteristics

non-systemic
non-selective

A. Non-residual

methyl bromide
chloropicrin
carbon disulfide

B. Residual

Vapam
Vorlex
Mylone

Classification of Nematicides

I. Organophosphates

A. Characteristics

organic
systemic
residual
selective

B. Examples

Dasanit
Nemacur

II. DBCP

A. Characteristics

organic
non-systemic
non-residual
non-selective

B. Example

Nemagon

Labels and Labeling

INTERPRETING LABEL INFORMATION

By law, every pesticide sold to the public must be placed in a container and the container must bear a label which clearly states certain information. If the product is sold across state lines, the label must be registered by the Pesticide Regulation Division of the United States Department of Agriculture (USDA). There are rare instances where smaller companies produce chemicals which are marketed only within a given state. Federal label approval is not required in such cases, but most states have initiated their own labeling laws to cover this situation. Generally, state regulations for label information conform to those of the USDA.

Reading and understanding a label can be simplified by knowing what standard information can be found on a label. This information includes:

1. Brand name
2. Type of formulation
3. Ingredient statement
4. Common name
5. Chemical name
6. Net contents
7. Name and address of the manufacturer
8. EPA Registration number
9. Establishment number
10. Precautionary statements
11. Signal words and symbols
12. Statement of practical treatment
13. Statement of use classification
14. Directions for use
15. Misuse statement
16. Reentry statement
17. Category of applicator
18. Storage and disposal directions

LABELS AND LABELING

All the printed information you get about a pesticide product from the company or its agent is called labeling. Labeling includes such things as -

a. the label on the product
b. brochures
c. flyers
d. other printed information handed out by your dealer.

The label is the information printed on or attached to a container of pesticides. The label will tell you:

a. how to use the product correctly
b. what special safety measures you should take.

Parts of the Label

Brand Name

Each company uses brand names to identify its products. The brand name shows up plainly on the front panel of the label.

Type of Formulation

Different types of pesticide formulations (such as liquids, wettable powders, and dusts) require different methods of handling. The label will tell you what type of formulation the package contains. The same pesticide may be available in more than one formulation.

Ingredient Statement

Every pesticide label must list what is in the product. It tells you the names and amounts of the active ingredients and the amount of inert ingredients.

Common Name

Many pesticides have complex chemical names. Some have been given another name to make them easier to identify. These are called common names. A chemical made by more than one company will be sold under several brand names, but you may find the same common name or chemical name on all of them.

Net Contents

The net contents number tells you how much is in the container. This can be expressed in gallons, pints, pounds, quarts, or other units of measure.

Name and Address of Manufacturer

The law requires the maker or distributor of a product to put the name and address of the company on the label. This is so you will know who made or sold the product.

Registration Number

A registration number must be on every pesticide label. It shows that the product has been registered with the Federal Government.

Establishment Number

The establishment number tells what factory made the chemical. This number does not have to be on the label but will be somewhere on each container.

Precautionary Statements

Hazards to Humans (and Domestic Animals)

This section will tell you the ways in which the product may be poisonous to man and animals. It also will tell you of any special steps you should take to avoid poisoning, such as the kind of protective equipment needed.

If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning.

Environmental Hazards

The label tells you how to avoid hurting the environment. Some examples are:

a. "This product is highly toxic to bees exposed to direct treatment or to residues on crops."
b. "Do not contaminate water when cleaning equipment or when disposing of wastes."
c. "Do not apply where runoff is likely to occur."

Physical and Chemical Hazards

This section will tell you of any special fire, explosion, or chemical hazards that the product may have.

Signal Words and Symbols

Some pesticides may be hazardous to people. You can tell how toxic a product is by reading the signal word and symbol on the label.

Signal Words

Signal Words	Toxicity	Approximate Amount Needed To Kill the Average Person
DANGER	Highly toxic	a taste to a teaspoonful
WARNING	Moderately toxic	a teaspoonful to a tablespoonful
CAUTION	Low toxicity or Comparatively free from danger	an ounce to more than a pint

All products must bear the statement "Keep out of reach of children".

Symbol

The skull and crossbones is used on all highly toxic materials along with the signal word DANGER and the word POISON.

Statement of Practical Treatment

If swallowing or inhaling the product or getting it in your eyes or on your skin would be harmful, the label will tell you emergency first aid measures. It also will tell you what types of exposure require medical attention.

The pesticide label is the most important information you can take to the physician when someone has been poisoned.

Statement of Use Classification

Every pesticide label must show whether the contents are for general use or restricted use. The label will say:

"General classification"

or

"Restricted use pesticide for retail sale to and application only by certified applicators or persons under their direct supervision".

Directions for Use

The directions for use tell you:

a. the pests the product will control (If you cannot find a product that lists the pest you want to control, ask your dealer or Cooperative Extension agent. The label may use a different name for the pest than the one you use.)
b. the crop, animal, or other item the product can be used on
c. whether the product is for general or restricted use
d. how the product should be applied
e. how much to use
f. where the material should be applied
g. when it should be applied.

Misuse Statement

This section will remind you that it is a violation of Federal law to use a product in a manner inconsistent with its labeling.

Reentry Statement

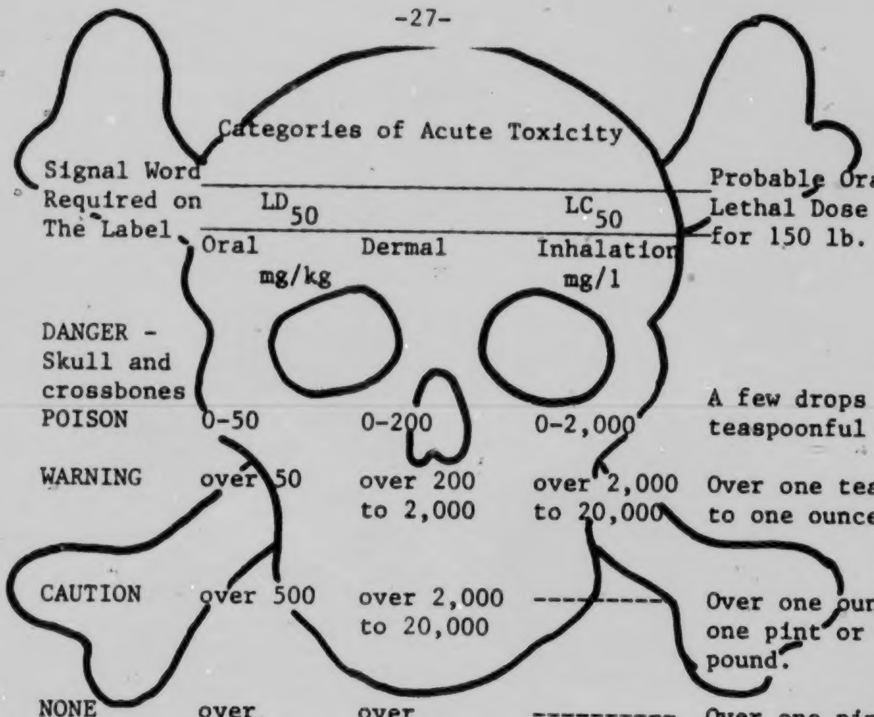
If required for the product, this section will tell you how much time must pass before a pesticide-treated area is safe for entry by a person without protective clothing. Consult local authorities for special rules that may apply.

Category of Applicator

If required for the product, this section will limit use to certain categories of commercial applicators.

Storage and Disposal Directions

Every pesticide should be stored and disposed of correctly. This section will tell you how to store and dispose of the product. Do not use a product on a crop or for a pest not listed on the label. Always use it at the recommended rate.



Categories of Acute Toxicity

Categories	Signal Word Required on The Label	LD_{50} Oral mg/kg	LD_{50} Dermal	LC_{50} Inhalation mg/l	Probable Oral Lethal Dose for 150 lb. man
I Highly Toxic	DANGER - Skull and crossbones POISON	0-50	0-200	0-2,000	A few drops to a teaspoonful
II Moderately Toxic	WARNING	over 50	over 200 to 2,000	over 2,000 to 20,000	Over one teaspoonful to one ounce.
III Slightly Toxic	CAUTION	over 500	over 2,000 to 20,000	----------	Over one ounce to one pint or one pound.
IV Relatively Non-toxic	NONE	over 5,000	over 20,000	----------	Over one pint or one pound

When Should You Read the Label?

Before you Buy the Chemical to Determine-

a. If this is the chemical you need for the job. Never purchase or select a pesticide based on the color of the label or product name (Raid, Ortho etc.). Labels of the same color and general makup may contain widely different active ingredients.
b. Whether this material is too toxic or hazardous to be used safely under your conditions.
c. Concentration in percent or pounds per gallon of active ingredient.
d. If the formulation is suitable for your equipment and the situation in which it will be applied.

Before You Prepare the Material for Use to Determine-

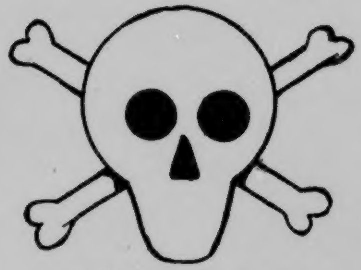
a. Protective equipment necessary when handling it.
b. Warnings and antidotes, when required.
c. What you can mix with it (compatibility).
d. How much to use.

Before Applying, to Determine-

a. Safety measures necessary for applicator.
b. To what it can be applied.
c. When to apply (including waiting period on crops and animals.).
d. How to apply.
e. Rate of application.
f. Restrictions of use.
g. Special instructions.

Signal Words

DANGER



POISON

Highly Toxic

WARNING

Moderately Toxic

CAUTION

Slightly Toxic to
Relatively Nontoxic

How Pesticides Harm the Environment

Here are some ways damage can occur.

Direct Kill

Fine mists of herbicide can drift to nearby crops or landscape plants and kill them. You can kill bees and other pollinators if you treat a crop with a pesticide while they are in the field. Or you could kill the natural enemies of pest insects.

Life in streams or ponds can be wiped out by –

a. accidental spraying of ditches and waterways.
b. runoff from sprayed fields.
c. careless tank filling or draining, or
d. careless container disposal.

If more than one pesticide will control the pest, choose the one that is the least hazardous to the environment and most useful for your situation. Ask your Cooperative Extension agent to help you make this choice.

Persistence and Accumulation

Not all pesticides act the same after you apply them. Most are in one of these two groups:

Pesticides that break down quickly remain in the environment only a short time before being changed into harmless products.

Pesticides that break down slowly may stay in the environment without change for a long time. They are called persistent pesticides.

Some persistent pesticides can build up in the bodies of animals, including man. These pesticides are called accumulative.

Pesticide Movement in the Environment

Pesticides become problems when they move off target. This may mean –

a. drifting out of the target area in the form of dust or mist
b. moving on soil particles by erosion
c. leaching through the soil
d. being carried out as residues in crops and livestock
e. evaporating and moving with air currents.

Transportation of Pesticides

You are responsible for the safe transport of your pesticide.

a. The safest way to carry pesticides is in the back of a truck. Fasten down all containers to prevent breakage and spillage.
b. Keep pesticides away from food, feed, and passengers.
c. Pesticides should be in their original labeled packages. Keep paper and cardboard packages dry.
d. If any pesticide is spilled in or from the vehicle, clean it up right away. Use the correct cleanup method.
e. Do not leave unlocked pesticides unattended. You are responsible if accidents occur.

Pesticide Storage

The label will tell you how to store the product.

The storage place should keep the pesticides dry, cool, and out of direct sunlight.

The storage place should have -

a. fire-resistant construction, including a cement floor
b. an exhaust fan for ventilation
c. good lighting
d. a lock on the door

Keep the door locked when the building is not in use.

Store all pesticides in the original labeled containers.

Do not store them with food, feed, seed, or animals.

Check every container often for leaks or breaks. If one is damaged, transfer the contents to a container that has held exactly the same pesticide. Clean up any spills. Use correct cleanup methods.

Mixing and Loading Pesticides

Keep livestock, pets, and people out of the mixing and loading area.

Work outdoors. Do not work alone. Choose a place with good light and ventilation. Do not mix or load pesticides indoors or at night unless there is good lighting and ventilation.

Before handling a pesticide container, put on the correct protective clothing and equipment.

Each time you use a pesticide, read the directions for mixing. Do this before you open the container. This is essential. Directions, including amounts and methods, may have changed since you last used the product.

When taking a pesticide out of the container, keep the container and pesticide below eye level. This will avoid a splash or spill on your goggles or protective clothing.

If you splash or spill a pesticide while mixing or loading:

a. stop right away.
b. remove contaminated clothing.
c. wash thoroughly with detergent and water. Speed is essential.
d. use correct cleanup methods to clean up the spill.

When mixing pesticides, measure carefully. Use only the amount called for on the label. Mix only the amount you plan to use.

When loading pesticides, stand so the wind blows across your body from the right or left to avoid contaminating yourself.

To prevent spills, replace all pour caps and close containers after use.

Pesticide Application

Wear the protective clothing and equipment the label requires.

To prevent spillage of chemicals, check all application equipment for -

a. leaking hoses, pumps or connections
b. plugged, worn, or dripping nozzles

Use water to calibrate your spray equipment before use.

Before starting a field application, clear all livestock and people from the area to be treated.

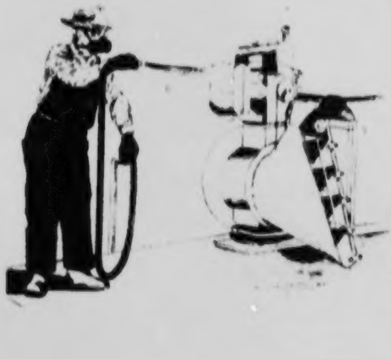
Drift is the movement of spray droplets or dust particles away from the target area. To minimize drift, apply pesticides only on days with light breezes. If moderate to strong winds come up while you are working, stop immediately.

You also can reduce drift by spraying at the lowest practical pressure and using the largest practical nozzle openings for the job you are doing.

Vaporization is the evaporation of an active ingredient during or after application. Pesticide vapors can cause injury far from the site of application. High temperatures increase vaporization. You can reduce vaporization by -

a. choosing pesticide formulations that do not evaporate easily
b. spraying in the cooler parts of the day.

Cleaning Equipment



Mixing, loading, and application equipment must be cleaned as soon as you finish using it. Clean both the inside and outside. Wear the protective clothing you would wear for mixing pesticides.

Take special care if you must make equipment repairs before the equipment is completely cleaned.

Have a special area for cleaning. It is best for the area to have a wash rack or concrete apron with a good sump. This will catch all contaminated wash water and pesticides. Dispose of sump wastes by burning or burial as you would excess pesticides. Keep drainage out of water supplies and streams.

Disposal (See page 59 for more detailed disposal instructions)

Excess Pesticides

If you have excess diluted pesticides or pesticides in their original container:

a. Use them up according to label directions; if you cannot,
b. bury them in a special landfill or store them until you can.

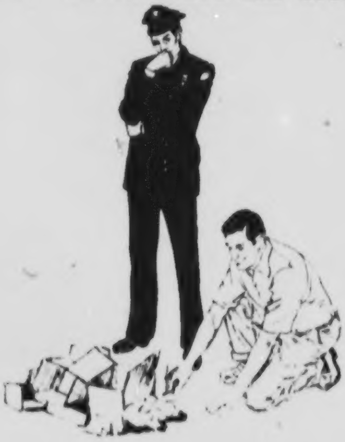
Empty Containers

Rinse and drain all metal, plastic, or glass container this way:

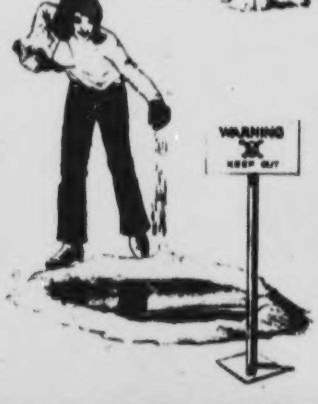
1 -Empty the container into the tank. Let it drain an extra 30 seconds.
2 -Fill it one-fifth to one-fourth full of water.
3 -Replace and tighten the closure and shake the container. Upend the container so the rinse reaches all the inside surfaces.
4 -Drain the rinse water from the container into the tank. Let the container drain for 30 seconds after emptying.
5 -Repeat steps 2,3, and 4 two more times.

You can bury rinsed containers singly in open fields. Puncture or break the containers before burying them. Bury them at least 18 inches below the surface where they will not pollute surface or subsurface water. Or you can dispose of empty rinsed containers in a sanitary landfill. Check state and local regulations.

You may burn small numbers of paper containers in open fields. Stay out of fumes and smoke. Be sure your state and local regulations permit open burning.



Cleaning of Spills



Keep people away from spilled chemicals. If the pesticide was spilled on anyone, give the correct first aid.
Confine the spill. Dike it up with sand or soil if necessary.
Use an absorbent material to soak up the spill. You can use soil, sawdust, or a special product made to do this. Shovel all contaminated material into a leak-proof container for disposal. Dispose of it in a special landfill.

If the spill is on a state highway, call the highway patrol.

If the spill is on a county road or a city street, call the county sheriff or city police.

If water is contaminated, notify your county health officials.

Safe Entry Times

It may be dangerous for an unprotected person to enter an area immediately after some pesticides have been used. The time that must pass before the area is safe for a person without protective clothing is called a safe-entry time, or reentry period. This time is given on the label of each pesticide that may cause a reentry problem. Reentry may pose special problems in some areas. Check with local authorities for any special rules that may apply.

SAFETY

Understanding Toxicity

All pesticides are poisonous (toxic) to a certain degree. There is, however, a great range in the levels of toxicity among the more than 900 compounds available on today's market.

The most common measure of toxicity of a chemical is the value known as "LD_{50}". This means the amount of a chemical required to kill 50 per cent of a large population of test animals. In addition, the LD_{50} value is based upon the amount of pure chemical in milligrams per kilogram of body weight (LD_{50} mg/kg) given to the test animal in one internal dose. There are two basic ratings used -- "oral" (given internally) and "dermal" (applied to skin with 24-hour exposure). Regardless of the rating used, the larger the LD_{50} figure, the less toxic the chemical (see list of toxicity ratings).

The class ratings can be deceptive since one chemical can be 50 or more times as toxic as another and still fall within the same class. If, for instance, a person weighing 180 pounds ingested a chemical with an LD_{50} of 1, a dosage of 0.003 oz. would have a 50% possibility of causing death. Another chemical in the same class with an LD_{50} of 50 would require 0.15 oz. (4.26 grams) to cause a similar possibility of death. Toxicity is the potential killing power of the pesticide.

Hazard Is the Risk of Danger. It is the chance that danger or harm will come to the applicator or bystanders or consumers or livestock or wildlife or crops, etc, from the use of a pesticide. Hazard is often confused with toxicity. They are not the same. A highly toxic pesticide is usually considered "hazardous" because of the high risk that the applicator, bystanders, etc, can be injured. However, safe and careful handling of a highly toxic pesticide can make it a low risk or low hazard. Many factors besides toxicity can make a pesticide hazardous. These include the target involved, the formulation chosen, the concentration and dosage used, the type of pesticide, and the skill of the applicator.

ORAL AND DERMAL TOXICITY RATINGS FOR SELECTED CHEMICALS

		LD_{50} - mg/kg		
		Oral	Dermal	Probable oral letha dose for 150 lb man
Class 1.	Highly toxic	1-50	1-200	Few drops to 1 tsp
Class 2.	Moderately toxic	50-500	200-2,000	1 tsp to 1 oz
Class 3.	Low toxicity	500-5,000	2,000-20,000	1 oz to 1 pt (1 lb)
Class 4.	Very low toxicity	over 5,000	over-20,000	1 pt to 1 qt (2 lbs)

Classes 3 and 4 are generally considered of low hazard, even for the homeowner who usually does not have proper protective equipment.

Symbols Used in Tables

S = Severe reaction
M = Mild reaction
L = Little or no reaction to dosages tested

P = Persistent and accumulative pesticides
H = Highly toxic pesticides
G = Greater than

Brand names begin with upper case letters; generic names, with lower case.

Name	Oral LD_{50}	Dermal LD_{50}
Fumigants		
chloropicrin (Chlor-O-Pic, Picfume)	.8 mg/liter	S,H
methyl bromide (Dowfume)	1 mg/liter	S,H
Fungicides		
anilazine (Dyrene)	2710	M
benomyl (Benlate, Tersan 1991)	9590	L
captan (Orthocide)	9000-15,000	L
chloroneb (Tersan SP)	11,000	5,000,G
chlorothalonil (Daconil 2787)	3750	10,000,G
cycloheximide (Acti-dione)	1.8-2.5	S,H
dinocap (Karathane)	980-1190	9400
DMTT (Mylone)	500-650	M
fenaminosulf (Dexon)	60	M
folpet (Phaltan)	10,000	M,G
lime	7340	M
maneb	6750-7500	1000,G
methyl thiophanate (Fungo)	9700	?
nabam (Ortho-Nabam)	395	1000,G

Name	Oral LD_{50}	Dermal LD_{50}
Fungicides (Cont'd)		
PCNB (Terraclor)	1650-2000	M
SMDC (Vapam)	820	800
sulfur	17,000	M,G
Terrazole or Koban	2000	?
thiabendazole (Mertect 160F)	3100	?
thiram (Tersan 75)	780	S
Vorlex	305	M
zinc iron maneb (Fore, Tersan LSR)	8000	8000,G
zineb (Ortho-Zineb)	5200	1000,G
ziram	1400	1000,G
Growth Retardants		
chlorflurenol (Maintain CF 125)	6400	?
maleic hydrazide	6951	?
Herbicides		
amitrole	5000-15,000	10,000,G
atrazine	3080	10,200
benefin (Balan)	10,000	?
bensulide (Betasan, Pre-San)	1082	?
bromacil (Hyvar X)	5200	5000,G
bromoxynil (Brominal, Buctril)	190-270	M
calcium arsenate (Chip-Cal)	35-100	?
2,4-D	375-800	800-1500
dalapon (Dowpon)	7570	M
DCPA (Dacthal)	3000	10,000
dicamba (Banvel D)	1029	M
dichlobenil (Casoron 133)	3160	?
diquat	400-440	?
MCPA	650-700	1000,G
MCPP or mecoprop	930	?
monuron (Telvar)	3500-3600	M
paraquat	157	M,H
siduron (Tupersan)	7500	?
silvex, 2,4,5-TP	650	?
2,4,5-T (Dacamine, Weedon)	481-500	M,H
terbutol (Azak)	34,000	?
trifluraline (Treflan)	3700-10,000	5000,G

Name	Oral LD$_{50}$	Dermal LD$_{50}$
Insecticides		
calcium arsenate (Chip-Cal)	35-100	?
carbaryl (Sevin)	500-850	4000,G
carbophenothion (Trithion)	32.2	?
chlordane	335-430	690-840,P
chlorpyrifos (Dursban)	163	?
diazinon	76-108	455-900
dieldrin	46	60-90,P
ethion (Ethodan)	27-65	62-245,H
lead arsenate	1050	2400,G,P
lindane	88-91	900-1000
malathion	100-1374	4444,G
methoxychlor (Marlate)	5000	6000,G,H
methyl parathion (Dalf)	14-24	67
milky disease spores (Doom)	-----	?
parathion	4-13	7-21,H
trichcrfon (Dylox)	560-630	2000,G
Nematicides		
D-D mixture (Nemafene)	140	2100
dibromochloropropane (Nemagon)	172	1420
ethoprop (Mocap)	61.5	?
fensulfothion (Dasanit)	2-11	3-30,H
Other		
aspirin	750	-------
caffein (coffee, tea)	200	-------
ethyl alcohol	4500	-------
table salt	3320	-------

PROTECTING CREW WORKERS

The use of protective clothing and other safety devices offers a considerable degree of protection against skin and lung contamination of the applicator, but these items do not eliminate the necessity for other precautions. Coveralls, rainsuits, head and neck coverings, boots, goggles, gloves, creams and lotions, etc., are designed to prevent direct contact with chemicals. They must, however, be used properly and whenever necessary, not simply during the application process.

Many superintendents are alert to the dangers present when applying pest control chemicals but overlook these equally hazardous situations:

1. Handling of containers (moving from transport vehicle to storage area or rearranging containers in the storage area)
2. measuring, loading or mixing operations
3. disposal of empty containers (see section dealing with disposal procedures)
4. cleaning of equipment after use
5. laundering of contaminated clothing
6. insisting that workers wash or shower thoroughly and change to clean clothing after handling chemicals.

When moving chemical containers to or from storage areas on a large scale, workers should wear the proper type of gloves and rubberized boots. DO NOT PERMIT COTTON OR LEATHER GLOVES, CANVAS OR LEATHER BOOTS, OR BOOTS OPEN AT THE TOP TO BE WORN. Cotton, leather and canvas will absorb large quantities of toxic materials and provide a constant exposure to the skin. The same holds true for felt or other absorbent type hats. If organophosphorus or carbamate insecticides are involved, wear natural rubber gloves (unless the container label specifically states otherwise). Even though new, gloves can have pinpoint holes, and this can be checked by filling each glove with water and squeezing. If water comes out, do not use for handling chemicals.

Rubberized boots are generally preferred for protection against chemicals because they wear well and can be cleaned with soap and water. Some superintendents have successfully used vinyl boots since they are lightweight and usually less expensive than pure rubber or rubberized boots. The new "throw-away" plastic boots and gloves should not be used since they may not be strong enough to stand the rough conditions of continuous usage.

Workers need additional protection when opening containers, mixing chemicals, and/or filling application equipment. The operations involve direct skin or lung exposure to the chemicals. Therefore, goggles or face shields, head coverings, and/or respirators should be worn. It is advisable to wear a rainsuit or coveralls for maximum protection, especially when very toxic chemicals are being handled. Goggles and face shields should have the headbands replaced periodically since they are absorbent and are in direct contact with the skin and hair. Don't forget to wear your gloves and respirator when handling concentrated pesticides during mixing and filling operations.

Maximum protection is needed when chemicals are being applied, and the type of protection is dependent upon the type or types of chemicals being used. In spraying operations, operators are often exposed to considerable hazard because their clothing can become very wet. The use of waterproof rainsuits is recommended for the greatest degree of protection. If dusts or granular materials are being used, full-length coveralls are satisfactory. Both wet and dry applications will require the use of respirators, gloves, boots, and head and neck covering for maximum protection. Have pant legs over the boots and shirt sleeves over the gloves - not "tucked in".

There is a moderately high risk factor involved in the cleaning of equipment after use. Quite often the workers are eager to shed the protective clothing as soon as they return to the maintenance building, especially on hot days when most pesticides are applied. Every effort must be made to prevent such a practice, since the normal splashing and spilling of contaminated water onto bare skin or clothing can lead to serious consequences. Protective clothing suggested during clean-up includes rubberized boots, rubber gloves, goggles or face shield, and waterproof suit or large rubberized apron.

If, for any reason, a worker must put his head into a spray tank or other closed-space piece of equipment, he should wear a suitable respirator.

All clothing should be thoroughly washed with soap and water after each usage. This includes gloves, boots, coveralls, waterproof suits, etc. If inner clothing is wet or contaminated with dry-type chemicals, it, too, should be washed. Respirators should be disassembled, the facepieces washed with warm, soapy water and then carefully rinsed and dried. Filters in respirators should be changed twice daily or when breathing becomes difficult.

Cartridges in respirators should be replaced after eight hours of actual use or sooner if any odor of the chemical is detectable. Respirator manufacturers give cartridge life information on their labels. Headbands should be changed often or, if washable, washed after every use. Plastic head bands are preferable.

The final safeguard is that of personal cleanliness -- each person who has handled toxic chemicals must be instructed to wash or shower thoroughly as soon as possible after finishing his work. Failure to do so can produce tragic results, especially if the worker is unduly sensitive to a given chemical. Some pesticides accumulate in your body after repeated exposure and may cause illness or death.

If the foregoing seems unreasonable, bear in mind that you, as a professional superintendent, are completely responsible for the health and safety of your crew. The use of protective clothing and other devices should be a stipulation of employment that is clearly understood by each employee--just as a welder understands that he must wear goggles or a face shield if he is to avoid severe eye damage. Several states have enacted legislation with respect to protective clothing and respiratory devices which must be worn by all persons who handle toxic chemicals. The alert superintendent will keep abreast of these laws by checking with his local county agent or with state experiment station personnel.

RECOGNIZING PESTICIDE POISONING

Pesticides can make you or one of your staff sick and you should know how to recognize the early stages of pesticide poisoning. IF YOU OR ANY OF YOUR CREW DEVELOP ANY OF THESE SYMPTOMS, GET TO A DOCTOR AT ONCE. Remember, however, that just because a person has been around pesticides and becomes sick is no proof that pesticides made him sick.

If a person is suspected of being poisoned by a pesticide, immediately remove him from the source of the pesticide. Remove all contaminated clothing. By so doing you may prevent additional exposure and reduce the injury. If the person shows any signs of poisoning take him to a doctor immediately. Take the pesticide container with you so the doctor will know how to treat the patient.

Antidotes are remedies that may relieve or neutralize pesticide poisoning. Clean water dilutes and helps wash away poisons. Soap and water for washing the skin is a valuable antidote for external use. Antidotes for internal use on specific pesticides are suggested on many pesticide labels but should be used only by physicians or others trained in their proper use. Improper use or the use of antidotes to counteract poisoning can be as harmful as the poison itself. Atropine, 2-PAM and other antidotes should only be given under a physician's direction.

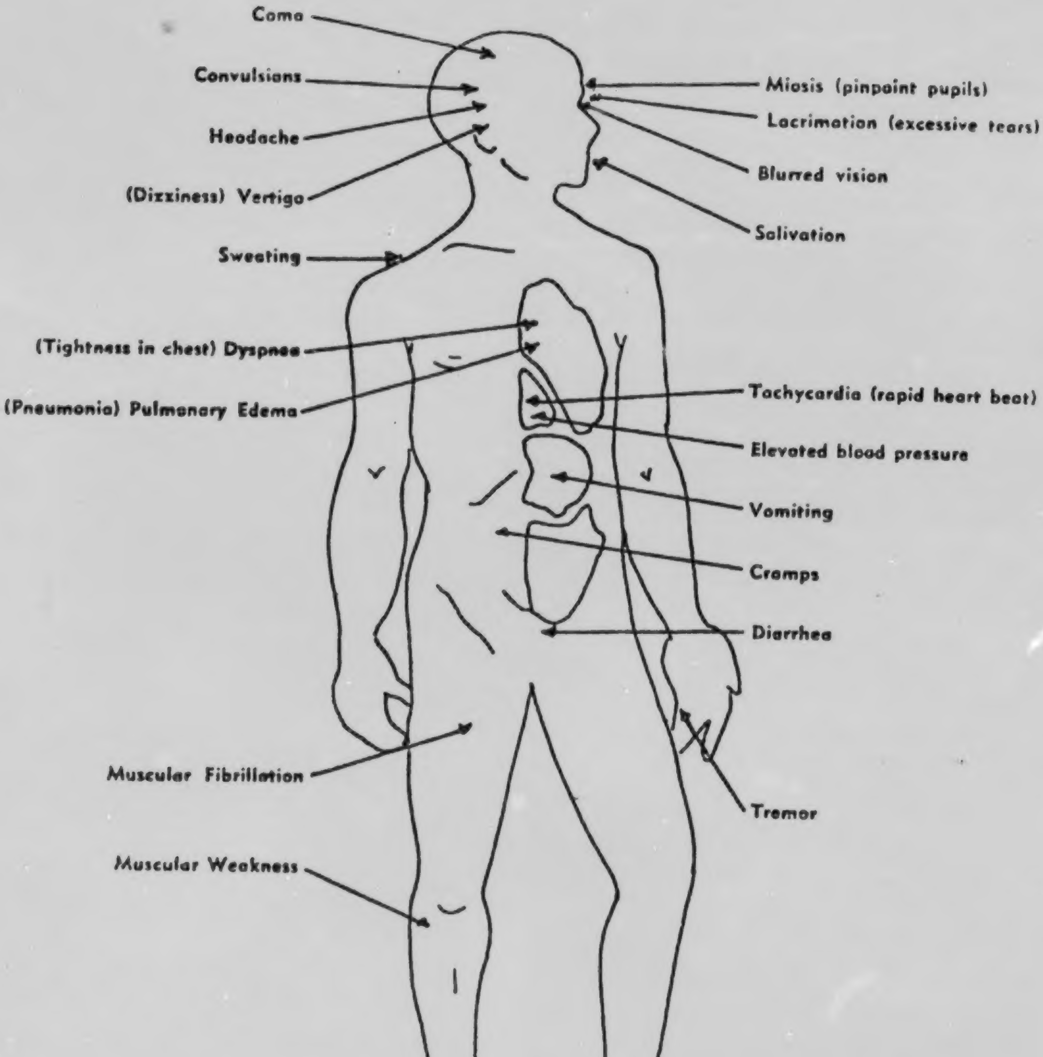
Learn how to recognize poisoning symptoms. Listed below are some of the more important hazardous pesticide groups and some of the ways they affect humans or animals.

POISONING SYMPTOMS
Carbamate and organophosphate pesticides:

1. Mild Poisoning
    - a fatigue
    - b headache
    - c dizziness
    - d blurred vision
    - e too much sweating and salivation
    - f nausea and vomiting
    - g stomach cramps and diarrhea
2. Moderate Poisoning
    - a unable to walk
    - b weakness
    - c chest discomfort
    - d muscle twitches
    - e constriction of eye pupils
    - f earlier symptoms become more severe
3. Severe Poisoning
    - a unconsciousness
    - b severe constriction of pupil of eye
    - c muscle twitches
    - d secretions from mouth and nose
    - e breathing difficulties
    - f death if not treated

Illness may occur a few hours after exposure. But if symptoms start more than 12 hours after you were exposed to the pesticide you probably have some other illness. Check with your physician to be sure.

SYMPTOMS OF PESTICIDE POISONING


Coma
Convulsions
Headache
(Dizziness) Vertigo
Sweating
(Tightness in chest) Dyspnea
(Pneumonia) Pulmonary Edema
Muscular Fibrillation
Muscular Weakness
Miosis (pinpoint pupils)
Lacrimation (excessive tears)
Blurred vision
Salivation
Tachycardia (rapid heart beat)
Elevated blood pressure
Vomiting
Cramps
Diarrhea
Tremor

Some examples of the chemicals in the various groups are contained in the Pesticide Section of this manual.

Organophosphorus Pesticides

These pesticides, which as a rule are the most toxic, are mainly insecticides and contain phosphorus. The pesticides in this group attack a chemical in the blood, cholinesterase, that is necessary to proper nerve functioning. Therefore, the organophosphorus pesticides are considered inhibitors of cholinesterase.

When a person's cholinesterase is "tied up" with these pesticides, his nerves continue to send messages to certain muscles which make them move (twitch) constantly. Other symptoms of poisoning from these compounds are "pinpoint" pupils, watery eyes, drooling, dizziness, excessive sweating, rapid heartbeat, vomiting, stomach cramps and diarrhea. Severe symptoms are difficult breathing, loss of ability to use muscles and control bowel movements, and unconsciousness (coma). Even in the advanced stages of poisoning persons can be saved with immediate and proper medical treatment. It is a good practice to have a "cholinesterase level" test run by a physician for those who regularly use carbamates and organophosphorous pesticides, so that in the event of accidental poisoning the "normal" level can be compared to their level after exposure.

Carbamate Pesticides

Poisoning symptoms of the carbamate insecticides are similar to those of organophosphorus materials. These cholinesterase inhibitors, however, do not "tie up" the cholinesterase as tightly or as long as the phosphates. Thus, repeated exposure for several days will not result in an accumulated toxic dose as may be the case with phosphates.

Chlorinated Hydrocarbon Pesticides (Organochlorines)

These compounds, containing chlorine, carbon and hydrogen, act on the central nervous system. Large doses cause diarrhea and vomiting and have caused liver and kidney damage in animals. Nervousness and convulsions may occur. While some of these compounds are long lasting and tend to accumulate in the body tissue, they are not generally as hazardous to man as the organophosphorus and carbamate insecticides. These compounds vary in their toxicity and persistence.

Nitrophenol Pesticides

These pesticides speed up certain body processes which may cause fever, sweating, rapid breathing, rapid heartbeat, or unconsciousness. These symptoms may occur rapidly. If death occurs it will usually happen within 48 hours. With the proper medical attention a patient can recover. In chronic (long lasting) cases patients may show nervousness, sweating, unusual thirst or loss of weight.

Arsenic Pesticides

These compounds, which contain arsenic, poison cells in certain body tissues when taken orally. They also affect certain enzymes thereby slowing down normal body functions. Symptoms are stomach pain, vomiting, diarrhea and a severe drop in blood pressure which may cause dizziness. Because of their toxic and persistent properties, some of the uses of these compounds have been restricted.

Mercury Pesticides

Mercury compounds poison the contents of certain body cells. Severe skin problems may occur. Mercury accumulates in the body and may cause permanent damage to the nervous system. Symptoms may be delayed and show up first as tingling of the fingers, tongue and lips, headache and shakiness. Inability to think clearly, write, speak or walk may occur. Changes in personality follow. People exposed to repeated doses of mercury should be under medical supervision. Because of their toxic and persistent properties, many of the uses of these compounds have been banned.

Botanical (Plant Derived) Pesticides

These pesticides range from pyrethrum, one of the safest pesticides to humans, to strychnine which is extremely hazardous to humans. Other examples are rotenone and nicotine.

Strychnine acts on the nervous system. Symptoms are extreme nervousness, stiff muscles in the face and legs, cold sweats, and fits. From one to ten violent attacks may occur before the patient either recovers or death follows due to his inability to breathe. Without medical attention death commonly occurs within 3 to hours after exposure, due to asphyxiation.

Nicotine is one of the most toxic of all poisons. It works on the nervous system and can cause poisoning by oral, dermal and respiratory exposure. Symptoms may show up as local skin burns and irritation. Poisoned persons may become excited followed by an extremely depressed feeling. Death may occur within 5 minutes to one hour after exposure.

Rotenone causes mild irritation of the eyes and skin. Cases of poisoning in man are rare. If rotenone dust is inhaled severe irritation of the nose, throat and lungs may occur.

Anticoagulants

These pesticides, commonly used as rodenticides, may reduce the body's ability to produce blood clots and damage tissues which carry blood. Large doses would be required to cause human death. Vitamin K, a coagulant, is the usual antidote for this type of poisoning.

Methyl Bromide, Chloropicrin and Carbon Tetrachloride

Methyl bromide can produce burns on the skin, pneumonia, kidney damage and extreme nervousness. Small amounts give the appearance of alcoholic intoxication. Victims have been jailed or sent to mental hospitals by mistake. Methyl bromide is an odorless, colorless gas and one of the most hazardous pesticides in use today.

Chloropicrin (tear gas) is a hazardous chemical but unlike methyl bromide it gives off a gas with an odor and is very irritating to the eyes. It is frequently mixed with methyl bromide as a warning agent.

Carbon Tetrachloride affects the nerves and severely damages the kidneys and liver.

Bipyridyliums

These herbicides (example, paraquat) may be fatal if swallowed and harmful if inhaled or absorbed through the skin. Lung fibrosis may develop if paraquat is taken by mouth or inhaled. Symptoms of injury may be delayed. Prolonged skin contact will cause severe irritation.

How You Might Be Poisoned by a Pesticide

By Mouth (oral)

Examples:
- -- not washing hands before eating, smoking or chewing
- -- mistaking the pesticide as food or drink--especially children
- -- accidentally applying pesticides to food
- -- carelessly or accidentally splashing in the face

By Skin Absorption (dermal)

Examples:
- -- by accidentally splashing or spraying the skin with a pesticide
- -- by allowing pesticide-contaminated (wet) clothing to touch the skin
- -- by applying pesticides in windy conditions
- -- by wearing pesticide-contaminated clothing
- -- by spilling the pesticide in a concentrated form during mixing and filling operations.

By Breathing Vapors (inhalation)

Examples:
- -- by accidentally contacting gaseous pesticides
- -- by constant exposure to poisonous materials in closed spaces
- -- by constant breathing of fumes from pesticides while applying them without protective equipment
- -- by using inadequate or faulty respiratory equipment.

FIRST AID FOR POISONING

The aim of treatment is to prevent the body from absorbing more poison. Do this by removing, diluting or slowing the movement of the poison.

Speed is essential. Begin the proper treatment at once. The one to use depends on the kind of poison or poisoning involved.

When possible, one person should give first aid while another arranges to get the victim to a hospital. If you are alone, let the time needed to get to medical aid, the condition of the victim, and the nature of the poison suggest what you should do first. Again, haste in reducing the concentration of poison is essential.

Knowing which poison to treat for will aid the physician. Take the poison container along and give it to him. If the container cannot be moved the label will do. If a label is not available, take along a sample of the poison. When the poison is not known, save and take a sample of the vomitus to the hospital.

I. SWALLOWED POISON

In all cases, except those listed below, REMOVE POISON FROM VICTIM'S STOMACH IMMEDIATELY by causing him to vomit. Do this as quickly as possible--it can be a lifesaving measure. How to cause vomiting is explained in section I-A.

DO NOT CAUSE VOMITING IF PATIENT

1. Is unconscious or in coma (See section I-B)
2. Is having fits (convulsions). (See Section I-B)
3. Has swallowed a petroleum product (gasoline, kerosene, lighter fluid or charcoal starter). (See Section I-C)
4. Has swallowed a corrosive (acid or alkaline) poison. Symptoms: severe pain, burning sensation in mouth and throat, possible vomiting. (See Section I-D)

A. CAUSE THE PATIENT TO VOMIT -- if none of the above conditions exist.

1. Give an antidote quickly.
   Give thick soup of water mixed with activated charcoal or universal antidote (½ ounce in ½ glass warm water) to absorb poison. (See formula for universal antidote on page 51). Or give milk or water to dilute poison (1 to 2 cups up to 5 years old; over 5 years give up to 1 quart), then -
2. Make patient vomit.
   Tickle back of throat with finger tip or blunt end of spoon.

   or

   Give an emetic: 2 tablespoons of salt in glass of warm water (give 1 or more glasses if needed or use Syrup of Ipecac) (use only according to instruction--see Section V).

   Note: When retching or vomiting begins, place the patient face down, head lower than hips to prevent vomitus from entering and injuring lungs.

3. Have patient drink more milk or water and vomit again until vomitus is clear liquid.
4. When all poison is removed by vomiting, repeat antidote or dilutant as in step No. 1.
5. Call physician or move patient to hospital if this has not been done.
6. Treat for shock if needed. (See Section V)

B. PATIENT UNCONSCIOUS OR HAVING FITS (Convulsions)

1. Do not try to make patient vomit.
2. Get to medical help immediately. Hospital emergency room is best.
3. Treat for shock if needed. (See Section V)

C. PETROLEUM PRODUCT SWALLOWED

1. Do not make patient vomit.
2. Get to medical help immediately. Hospital emergency room is best.
3. Give patient mineral oil to dilute poison and soothe burn. Do not give if it tends to cause gagging or vomiting.
4. Treat for shock if needed. (See Section V)

D. CORROSIVE POISON SWALLOWED

1. Do not make patient vomit.
2. Get to medical help immediately. Hospital emergency room is best.
3. If patient can swallow give proper temporary antidote while going to or waiting for medical aid.
4. Treat for shock if needed. (See Section V)

Temporary Antidotes for Corrosives

Check label or list below to learn if poison is acid or alkali. If acid swallowed -- give milk, milk of magnesia (1 tablespoon in 1 cup of water), or water.

If alkali swallowed -- give milk, fruit juice or water.

Amount to give: Children under 5, give 1 to 2 cups; over 5 give up to 1 quart.

Common Corrosives

Acid and acid-like -- sodium acid sulfate (toilet bowl cleaners), acetic acid (glacial), sulfuric acid, nitric acid, oxalic acid, hydrofluoric acid (rust removers), iodine, silver nitrite (styptic pencils).

Alkali -- sodium hydroxide (lye or drain cleaners), sodium carbonate (washing soda), ammonia water, sodium hypochlorite (household bleach).

II. POISON IN EYE (or Chemical Burn)

1. Hold eyelid open and wash with gentle stream of water for 5 or more minutes. Do immediately. A few seconds delay may seriously increase injury. Do not use any chemical to wash eye, or as treatment afterward.
2. Call a physician or take victim to hospital emergency room.
3. Treat for shock if needed. (See Section V)

III. POISON ON SKIN (or Chemical Burn)

1. Drench skin quickly and thoroughly with running water (do not use water on phosphorus burns). Use lots of water -- a hose, shower or faucet is better than drenching from a bucket.
2. Remove all clothing with poison or chemical on it. Apply stream of water to skin as clothing is removed.
3. With clothing removed bathe contaminated skin thoroughly. Speed in washing off contamination will limit injury. (Wash chemical burns gently but thoroughly; then cover burn area loosely with clean cloth.)
4. Call a physician or take victim to hospital emergency room.

5. Treat for shock if symptoms appear. (See Section V)

IV. INHALED POISON (dusts, vapors, gas)

1. Get patient to fresh air immediately. Do not allow to walk if at all possible.
2. Have someone call rescue unit or other medical aid.
3. Loosen tight clothing.
4. Give artificial respiration if breathing has stopped or is irregular, using mouth-to-mouth or mouth-to-nose method (see Section V). Continue until patient breathes normally or until help arrives. Do not inhale patient's breath.
5. Call physician if not already done, or take victim to hospital emergency room.
6. Keep patient quiet and treat for shock. (see Section V)

V. SUPPLEMENTAL TREATMENT AND USEFUL AIDS

A. TREATMENT FOR SHOCK

Symptoms: Cold, pale, sweaty skin, chilling, fainting or collapse.

1. Keep patient lying down.
2. Wrap warmly in blankets. Do not give alcohol in any form.
3. Give artificial respiration (see below) if breathing is irregular or has stopped.

B. ARTIFICIAL RESPIRATION (give if breathing has stopped or is highly irregular)

1. Use finger to clean victim's throat of mucus, vomitus or foreign object.
2. Place victim on his back.
3. Tilt victim's head back, stretching neck as far as possible to keep tongue out of airway.
4. With victim's lips closed, place your mouth to his nose and breathe into with smooth, steady pressure, until his chest starts to rise (or holding his nose closed, place your mouth on his and breathe into as above).
5. Remove mouth and allow victim's lungs to empty.
6. Repeat breathing treatment -- use shallow or deep breaths according to victim's size, at rate of 20 per minute. Use easy shallow puffs for infants, deeper breaths for adults. Do not stop until help arrives or normal breathing begins.

Note: If not getting air exchange, check to see that head is tilted back far enough. Cause may also be an obstruction in throat. To correct, turn victim on side and rap smartly between shoulder blades, or clear throat with finger and resume treatment.

C. USEFUL ANTIDOTES AND AIDS (to get and keep on hand)

Syrup of Ipecac -- used to promote vomiting. Poisonous if improperly used. Use only as directed by your physician. Have labeled with clear directions.
Activated Charcoal -- safe antidote which absorbs many poisons. Mix into thick soup (slurry) to give. Obtain from druggist.
Universal Antidote -- safe antidote which absorbs and neutralizes several poisons. Have druggist mix for you (2 parts of activated charcoal, 1 part magnesium oxide, 1 part tannic acid). A homemade universal antidote is 4 tablespoons of crumbled burnt toast (burn black), 2 tablespoons strong tea, 2 tablespoons milk of magnesia.
Atropine -- for users of parathion, TEPP and other organic phosphate pesticides. Consult physician about emergency supply. Dangerous if misused. Keep away from children and keep around only during spraying season. Do not use as a preventative. Workers should not carry atropine for first aid purposes. It should be given only under a doctor's direction.
2-PAM (Protopam Chloride) -- Injectable, should be used to counteract the effects of organophosphate poisoning. Never use for carbamate poisoning.

IN THE EVENT OF ANY POSSIBLE PESTICIDE POISONING CONTACT YOUR LOCAL PESTICIDE CONTROL CENTER OR YOUR PHYSICIAN. YOUR PHYSICIAN SHOULD BE ABLE TO GIVE YOU THE PHONE NUMBER OF YOUR PESTICIDE CONTROL CENTER. THESE PHONE NUMBERS SHOULD BE POSTED NEAR YOUR PHONE.

ARIZONA POISON CONTROL CENTERS*

CITY	Name and Address	Telephone
STATE COORDINATOR...	Albert L Picchioni, Ph.D. Professor of Pharmacology College of Pharmacy University of Arizona Tucson AZ 85721	884-1587 884-1428
Douglas.......	Poison Control Center Cochise County Hospital Rural Route #1 85607	364-7931
Flagstaff.....	Poison Control Center Flagstaff Hospital 1215 North Beaver Street 86001	774-5233 Ext. 255
Ganado........	Poison Control Center Project Hope Sage Memorial Hospital Box 457 86505	755-3411

City	Name and Address	Telephone
Kingman.......	Poison Control Center Mohave General Hospital 3269 Stockton Hill Road Kingman AZ 86401	757-2101 Ext. 245, 247
Nogales.......	Poison Control Center St. Joseph's Hospital Target Range Road P.O. Box 1809 85621	287-2771 Ext. 94
Phoenix.......	Poison Control Center Good Samaritan Hospital 1033 E McDowell Road 85006	252- 6611 Ext. 3711, 12, 3713
	Poison Control Center Maricopa County General Hospital 2601 E Roosevelt 85008	267-5411
	Poison Control Center Memorial Hospital 1200 S 5th Avenue 85003	252-5911 Ext. 391
	Poison Control Center St. Joseph's Hospital 350 W Thomas Road 85013	277-6611 Ext 3581
	Poison Control Center St. Luke's Hospital Medical Center 525 N 18th Street 85006	258-7373 Ext. 291
Prescott......	Poison Control Center Yavapai Community Hospital 1003 Willow Creek Road 86301	445-2700 Ext. 25
Tucson........	Arizona Poison Control Information Center College of Pharmacy University of Arizona 85721	882-6300
	Poison Control Center Pima County General Hospital 2900 S 6th Avenue 85713	792-8335
	Poison Control Center St. Mary's Hospital 1700 W St. Mary's Road 85703	622-5833 Ext 625 and 626

CITY	Name and Address	Telephone
Tucson (continued)		
	Poison Control Center Tucson Medical Center E. Grant Road at Beverly Blvd 85716	327-5461 Ext. 482
Winslow.......	Poison Control Center Winslow Memorial Hospital 116 E Hillview St 86047	289-4691
Yuma..........	Poison Control Center Yuma Regional Medical Center Avenue A and 24th St. 85364	344-2000 Ext. 221

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* Poison control centers as listed in the Directory of Poison Control Centers, Bureau of Product Safety, Division of Hazardous Substances and Poison Control, FDA, US Dept. HEW.

STORAGE AND DISPOSAL OF PESTICIDES

The following Rules and Regulations pertaining to the disposal and storage of pesticides and their containers are published by the EPA.

PESTICIDES AND CONTAINERS

Procedures Not Recommended

No person should dispose of or store (or receive for disposal or storage) any pesticide or dispose of or store any pesticide container or pesticide container residue:

a - In a manner inconsistent with its label or labeling.
b - So as to cause or allow open dumping of pesticides or pesticide containers.
c - So as to cause or allow open burning of pesticides or pesticide containers; except, the open burning by the user of small quantities of combustible containers formerly containing organic or metallo-organic pesticides, except organic mercury, lead cadmium, or arsenic compounds, is acceptable when allowed by State and local regulations.

d - So as to cause or allow water dumping or ocean dumping, except in conformance with regulations developed pursuant to the National Marine Protection, Research and Sanctuaries Act of 1972 (Pub. L92-352), and to Sections 304, 307, and 311 of the Federal Water Pollution Control Act as Amended (Pub. L-92-500).

e - So as to violate any applicable Federal or State pollution control standard.

f - So as to violate any applicable provisions of the Act.

Recommended Procedures for the Disposal of Pesticides

Recommended procedures for the disposal of pesticides are given below:

a. Organic pesticides, (except organic mercury, lead, cadmium, and arsenic compounds which are discussed in paragraph (c) of this section) should be disposed of according to the following procedures:

1. Incinerate in a pesticide incinerator at the specified temperature/dwell time combination, or at such other lower temperature and related dwell time that will cause complete destruction of the pesticide. As a minimum it should be verified that all emissions meet the requirements of the Clean Air Act of 1970 (42 U.S.C. 1857 et seq.) relating to gaseous emissions: specifically any performance regulations and standards promulgated under sections 111 and 112 should be adhered to. Any liquids, sludges, or solid residues generated should be disposed of in accordance with all applicable Federal State, and local pollution control requirements. Municipal solid waste incinerators may be used to incinerate excess pesticides or pesticide containers provided they meet the criteria of a pesticide incinerator and precautions are taken to ensure proper operation.

2. If appropriate incineration facilities are not available, organic pesticides may be disposed of by burial in a specially designated landfill. Records to locate such buried pesticides within the landfill site should be maintained.

3. The environmental impact of the soil injection method of pesticide disposal method should be undertaken only with specific guidance. It is recommended that advice be requested from the Regional Administrator in the region where the material will be disposed of prior to undertaking such disposal by this method.

4. There are chemical methods and procedures which will degrade some pesticides to forms which are not hazardous to the environment. However, practical methods are not available for all groups of pesticides. Until a list of such methods is available, it is recommended that advice be requested from the Regional Administrator in the region where the material will be disposed of prior to undertaking disposal by such method.

5. If adequate incineration facilities, specially designated landfill facilities, or other approved procedures are not available, temporary storage of pesticides for disposal should be undertaken. Storage facilities, management procedures, safety precautions and fire and explosion control procedures should conform to those set forth by the EPA.

6. The effects of subsurface emplacement of liquid by well injection and the fate if injection materials are uncertain with available knowledge, and could result in serious environmental damage requiring complex and costly solutions on a long-term basis. Well injection should not be considered for pesticide disposal unless all reasonable alternative measures have been explored and found less satisfactory in terms of environmental protection. As noted in the Administrator's Decision Statement No. 5, dated February 6, 1973, the Agency's policy is to oppose well injection of fluid pesticides "without strict controls and a clear demonstration that such emplacement will not interfere with present or potential use of the subsurface environment, contaminate ground water resources or otherwise damage the environment." Adequate pre-injection tests, provisions for monitoring the operation and the environmental effects, contingency plans to cope with well failures, and provisions for plugging injection wells when abandoned should be made. The Regional Administrator should be advised of each operation.

b. Metallo-organic pesticides (except organic mercury, lead, cadmium, or arsenic compounds which are discussed in paragraph (c) of this section), should be disposed of according to the following procedures:

   1. After first subjecting such compounds to an appropriate chemical or physical treatment to recover the heavy metals from the hydrocarbon structure, incinerate in a pesticide incinerator as described in paragraph (a) (1) of this section.
   2. If appropriate treatment and incineration are not available, bury in a specially designated landfill as noted in paragraph (a) (2) of this section.
   3. Disposal by soil injection of metallo-organic pesticides should be undertaken only in accordance with the procedure set forth in paragraph (a) (3) of this section.
   4. Chemical degradation methods and procedures that can be demonstrated to provide safety to public health and the environment should be undertaken only as noted in paragraph (a) (4) of this section.
   5. If adequate disposal methods as listed above in this section are not available, the pesticides should be stored according to the procedures in 165.10 until disposal facilities become available.
   6. Well injection of metallo-organic pesticides should be undertaken only in accordance with the procedures set forth in paragraph 165.8 (a) (6) of this section.

c. Organic mercury, lead, cadmium, arsenic, and all inorganic pesticides should be disposed of according to the following procedures:

   1. Chemically deactivate the pesticides by conversion to nonhazardous compounds, and recover the heavy metal resources. Methods that are appropriate will be described and classified according to their applicability to the different groups of pesticides.
   2. If chemical deactivation facilities are not available, such pesticides should be encapsulated and buried in a specially designated landfill. Records sufficient to permit location for retrieval should be maintained.
   3. If none of the above options is available, place in suitable containers (if necessary) and provide temporary storage until such time as adequate disposal facilities or procedures are available.

Recommended Procedures for the Disposal of Pesticide Containers and Residues

(a) Group I: Containers. Combustible containers which formerly contained organic or metallo-organic pesticides, except mercury, lead, cadmium, or arsenic compounds, should be disposed of in a pesticide incinerator, or buried in a specially designated landfill; except that small quantities of such containers may be burned in open fields by the user of the pesticide when such open burning is permitted by State and local regulations, or buried singly by the user in open fields with due regard for protection of surface and sub-surface water.

(b) Group II: Containers. Non-combustible containers which formerly contained organic or metallo-organic pesticides, except organic mercury, lead, cadmium, or arsenic compounds, should first be triple-rinsed. Containers in good condition may then be returned to the pesticide manufacturer or formulator, or drum reconditioner for reuse with the same chemical class of pesticide previously contained providing such reuse is legal under currently applicable US Department of Transportation regulations. Other rinsed metal containers should be punctured to facilitate drainage prior to transport to a facility for recycling as scrap metal or for disposal. All rinsed containers may be crushed and disposed of by burial in a sanitary landfill, in conformance with State and local standards or buried in the field by the user of the pesticide. Unrinsed containers should be disposed of in a specially designated landfill, or subjected to incineration in a pesticide incinerator.

(c) Group III: Containers. Containers (both combustible and noncombustible) which formerly contained organic mercury, lead, cadmium, or arsenic or inorganic pesticides and which have been triple-rinsed and punctured to facilitate drainage, may be disposed of in a sanitary landfill. Such containers which are not rinsed should be encapsulated and buried in a specially designated landfill.

(d) Residue disposal. Residues and rinse liquids should be added to spray mixtures in the field. If not, they should be disposed of in the manner prescribed for each specific type of pesticide.

Recommended Procedures and Criteria for Storage of Pesticides and Pesticide Containers

(a) General.

1. Pesticides and excess pesticides and their containers whose uncontrolled release into the environment would cause unreasonable adverse effects on the environment should be stored only in facilities where due regard has been given to the hazardous nature of the pesticide, site selection, protective enclosures, and operating procedures, and where adequate measures are taken to assure personal safety, accident prevention, and detection of potential environmental damages. These storage procedures and criteria should be observed at sites and facilities where pesticides and excess pesticides (and their containers) that are classed as highly toxic or moderately toxic and are required to bear the signal words DANGER, POISON, or WARNING, or the skull and crossbones symbol on the label are stored. These procedures and criteria are not necessary at facilities where most pesticides registered for use in the home and garden, or pesticides classed as slightly toxic (word CAUTION on the label) are stored. All facilities where pesticides which are or may in the future be covered by an experimental use permit or other special permit are stored should be in conformance with these procedures and criteria.

2. Temporary storage of highly toxic or moderately toxic pesticides for the period immediately prior to, and of the quantity required for a single application, may be undertaken by the user at isolated sites and facilities where flooding is unlikely, where provisions are made to prevent unauthorized entry, and where separation from water systems and buildings is sufficient to prevent contamination by runoff, percolation, or windblown particles or vapors.

(b) Storage Sites. Storage sites should be selected with due regard to the amount, toxicity, and environmental hazard of pesticides, and the number and sizes of containers to be handled. When practicable, sites should be located where flooding is unlikely and where soil texture/structure and geological/hydrologic characteristics will prevent the contamination of any water system by runoff or percolation. Where warranted, drainage from the site should be contained (by natural or artifical barriers or dikes), monitored, and if contaminated, disposed of as an excess pesticide. Consideration should also be given to containing wind-blown pesticide dusts or particles.

(c) Storage facilities. Pesticides should be stored in a dry, well ventilated, separate room, building or covered area where fire protection is provided. Where relevant and practicable, the following precautions should be taken:

1. The entire storage facility should be secured by a climb-proof fence, and doors and gates should be kept locked to prevent unauthorized entry.
2. Identification signs should be placed on rooms, buildings, and fences to advise of contents and warn of their hazardous nature, in accordance with suggestions given in paragraph (g) (1) (i) of this section.
3. All items of movable equipment used for handling pesticides at the storage site which might be used for other purposes should be labeled "contaminated with pesticides" and should not be removed from the site unless thoroughly decontaminated.
4. Provision should be made for decontamination of personnel and equipment such as delivery trucks, tarpaulin covers, etc. Where feasible, a wash basin, and shower with a delayed-closing pull chain valve should be provided. All contaminated water should be disposed of as an excess pesticide. Where required, decontamination area should be paved or lined with impervious materials, and should include gutters. Contaminated runoff should be collected, and treated as an excess pesticide.

(d) Operational procedures. Pesticide containers should be stored with the label plainly visible. If containers are not in good condition when received, the contents should be placed in a suitable container and properly relabeled. If dry excess pesticides are received in paper bags that are damaged, the bag and the contents should be placed in a sound container that can be sealed. Metal or rigid plastic containers should be checked carefully to insure that the lids and bungs are tight. Where relevant and practicable, the following provisions should be considered:

1. Classification and separation.

    I. Each pesticide formulation should be segregated and stored under a sign containing the name of the formulation. Rigid containers should be stored off the ground, in an orderly way, so as to permit ready access and inspection. They should be accumulated in rows or units so that all labels are visible, and with lanes to provide effective access. A complete inventory should be maintained indicating the number and identity of containers in each storage unit.

II. Excess pesticides and containers should be further segregated according to the method of disposal to ensure that entire shipments of the same class of pesticides are disposed of properly, and that accidental mixing of containers of different categories does not occur during the removal operation.

2. Container inspection and maintenance. Containers should be checked regularly for corrosion and leaks. If such is found, the container should be transferred to a sound, suitable, larger container and be properly labeled. Materials such as absorptive clay, hydrated lime, and sodium hypochlorite should be kept on hand for use as appropriate for the emergency treatment or detoxification of spills or leaks. (Specific information relating to other spill treatment procedures and materials will be published as it is confirmed.)

(e) Safety precautions. In addition to precautions specified on the label and in the labeling, rules for personal safety and accident prevention similar to those listed below should be available in areas where personnel congregate:

1. Accident prevention measures.

I. Inspect all containers of pesticides for leaks before handling them.
II. Do not mishandle containers and thereby create emergencies by carelessness.
III. Do not permit unauthorized persons in the storage area.
IV. Do not store pesticides next to food or feed or other articles intended for consumption by humans or animals.
V. Inspect all vehicles prior to departure, and treat those found to be contaminated.

2. Safety measures.

I. Do not store food, beverages, tobacco, eating utensils, or smoking equipment in the storage or loading areas.
II. Do not drink, eat food, smoke, or use tobacco in areas where pesticides are present.
III. Wear rubber gloves while handling containers of pesticides.
IV. Do not put fingers in mouth or rub eyes while working.
V. Wash hands before eating, smoking, or using toilet and immediately after loading, or transferring pesticides.
VI. Persons working regularly with organophosphate and N-alkyl carbamate pesticides should have periodic physical examinations, including cholinesterase tests.

(f) Protective clothing and respirators.

1. When handling pesticides which are in concentrated form, protective clothing should be worn. Contaminated garments should be removed immediately, and extra sets of clean clothing should be maintained nearby.

2. Particular care should be taken when handling certain pesticides to protect against absorption through skin, and inhalation of fumes. Respirators or gas masks with proper canisters approved for the particular type of exposure noted in the label directions should be used when such pesticides are handled.

(g) Fire Control.

1. Where large quantities of pesticides are stored, or where conditions may otherwise warrant, the owner of stored pesticides should inform the local fire department, hospitals, public health officials, and police department in writing of the hazards that such pesticides may present in the event of a fire. A floor plan of the storage area indicating where different pesticide classifications are regularly stored should be furnished with the home telephone numbers of:

    I. the person (s) responsible for the pesticide storage facility,
    II. the appropriate Regional Administrator, who can summon the appropriate Agency emergency response team,
    III. the U.S. Coast Guard, and
    IV. the Pesticide Safety Team Network of the National Agricultural Chemicals Association.

2. Suggestions for Fire Hazard Abatement.

    I. Where applicable, plainly label the outside of each storage area with "DANGER," "POISON", "PESTICIDE STORAGE" signs. Consult with the local fire department regarding the use of the current hazard signal system of the National Fire Protection Association.
    II. Post a list on the outside of the storage area of the types of chemicals stored therein. The list should be updated to reflect changes in types stored.

3. Suggested Fire Fighting Precautions.

    I. Wear air-supplied breathing apparatus and rubber clothing.
    II. Avoid breathing or otherwise contacting toxic smoke and fumes.
    III. Wash completely as soon as possible after encountering smoke and fumes.
    IV. Contain the water used in fire fighting within the storage site drainage system.
    V. Firemen should take cholinesterase tests after fighting a fire involving organophosphate or N-alkyl carbamate pesticides, if they have been heavily exposed to the smoke. Baseline cholinesterase tests should be part of the regular physical examination for such firemen.
    VI. Evacuate persons near such fires who may come in contact with smoke or fumes or contaminated surfaces.

STORAGE AND DISPOSAL OF PESTICIDES

Storage

Always store pesticides in a locked dry cupboard or storage shed where humans (especially children), livestock, and pets cannot come into unauthorized contact with them. Children and animals are curious. They don't know the hazards of these chemicals and they don't or can't read the labels.

Always store pesticides in the original, labeled container with the label plainly visible. Never store them in old bottles or food containers that could be mistaken for food or drink for humans or animals.

Do not store pesticides near food or feed.

Always keep lids and bungs tightened when containers are not being used.

Keep all "empty" pesticide containers in locked storage area until disposed of properly.

Containers should be periodically checked for corrosion, leaks, breaks, tears, etc, so that faulty containers may be disposed of or replaced before they constitute a hazard.

Do not permit anyone to sleep or eat in a room where pesticides are stored.

Install an exhaust fan for ventilation in storage rooms to help reduce high concentrations of toxic fumes and to hold temperatures down. Care should be exercised in locating these fans so that the exhaust does not contaminate the environment.

Fire and Explosion Hazards Involving Pesticides and Other Agricultural Chemicals

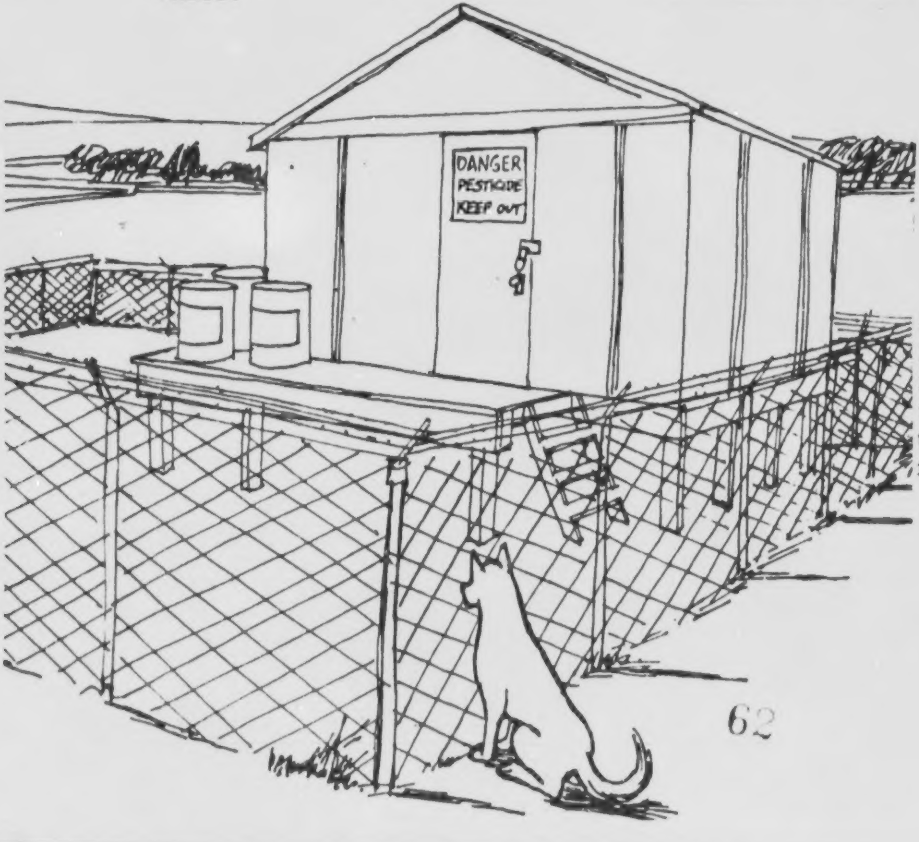
Interpretation 18. Revision II of Regulations for the enforcement of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) requires that fire hazard cautions be based on the flash point of the particular product. Formulations having flash points at or below 20° F must bear the statement, "DANGER-Extremely Flammable! Keep away from fire, sparks, and heated surfaces ". Chemicals with flash points above 80° F but not over 150° F will bear the statement, "Do not use or store near heat or open flame ".

When you purchase a pesticide, check the label for these warnings and make sure that you use and store such chemicals in accordance with directions to prevent the hazard of fires and explosions. Those compounds containing oils or aromatic petroleum distillates are the ones most likely to show such warnings. However, some powder formulations also present fire and/or explosion hazards. Examples are herbicides, desiccants, defoliants, and soil sterilants containing sodium chlorate. When a container of sodium chlorate is opened, the entire contents should be used. Do not attempt to store a partial container of this material. Certain wettable powder formulations of insecticides have been suspected of starting fires by spontaneous combustion.

Fires involving organophosphorus and carbamate insecticides as well as some fertilizers present great hazards to firemen and others in the vicinity.

The following suggestions will reduce such personal hazards.

1. Plainly label the outside of such warehouses on all sides with the word (s) "Danger" and/or "Poison" along with the familiar skull and crossbones, or simply "Pesticide Storage".
2. Post a list of the types of chemicals on the outside of the warehouse.
3. Keep the storage area or building locked at all times when not in actual use, to help reduce the possibilities of fires set by man.
4. Inform fire departments, hospitals, public health officials, and police departments, in writing, of the nature, quantities, and hazards these compounds may present in the event of fire. Ask the fire chief to inspect your facility at least once a year.
5. Keep the above department and officials informed by letter and phone of any major change in the nature, quantities, and hazards that those compounds may present in the event of fire.
6. The fire chief should be furnished with the home phone numbers of people responsible for the pesticide storage facility.
7. Glass containers of chemicals should not be placed in sunlight where they concentrate heat rays and start fires.
8. All combustible materials should be kept away from steam lines or other heating devices.
9. Use fire proofing material such as sheetrock in the building.
10. Install a sprinkler system in the storage building where possible when large quantities of such chemicals are to be stored.
11. Be thoroughly familiar with fire fighting equipment, alarms, and fire exits.



Store chemicals in a locked building. It is also well to have the lock high enough to make it difficult for youngsters to reach.

12. Fire fighting equipment should be checked periodically and ready for use at all times.
13. Locate such storage facilities as far as possible from other dwellings and populated areas.

Firemen Should be Instructed to

1. Wear air-supplied breathing apparatus, and rubber clothing when fighting such fires.
2. Avoid breathing or otherwise contacting toxic smoke and fumes whenever possible, to reduce hazards.
3. Wash completely as soon as possible after an encounter with smoke and fumes.
4. Wash clothing, boots and other equipment thoroughly after such a fire.
5. Have cholinesterase tests run after fighting a fire involving organophosphorus pesticides if they have been heavily exposed to the smoke.
6. Evacuate persons near such fires who may reasonably come in contact with smoke and fumes from the fire or contaminated surfaces.

Storage Life of Pesticides

Some pesticides such as DDT and other chlorinated hydrocarbons are very stable and can be stored for a number of years with little or no chemical change.

Some of the organophosphorus pesticides such as TEPP, parathion, and others, have a shorter storage life. Atmospheric conditions such as high temperatures and high humidity or sunlight may bring about a chemical breakdown or degradation of such materials, especially when they are in wettable powder or dust formulations. The labels of compounds subject to these reactions will warn of such limitations and generally will specify steps to be taken to avoid these reactions.

Some pesticides, and especially those formulated as liquid concentrates, are not to be stored at temperatures below those listed on the labels. Prolonged storage at low temperatures may result in crystallization or breakdown and the resultant material is even more toxic, phytotoxic, or will leave a higher residue.

It is not advisable to keep unsealed packages of powdered pesticides longer than one year; however, some pesticides in liquid form packaged in airtight containers may retain their effectiveness for several years if kept sealed.

If a pesticide has been stored for some time and doubt exists as to its effectiveness, try small quantities of it, according to label directions. If the treatment proves satisfactory, use the stored pesticide. If in doubt, discard the package.

Cross Contamination In Storage

In order to avoid the possibility of cross contamination of materials in storage, it is suggested that hormone type herbicides be stored in a separate building. They should not be stored near other pesticides, fertilizers, or seeds.

Disposal of Pesticides and Their Containers

Remember: "Empty" containers are never completely empty! They are like the "unloaded" gun, and are to be considered hazardous and treated as potential killers.

Importance

a. Hazard to children and unsuspecting persons.
b. Hazard to those who can't or don't read the label.
c. Hazard to animals. Domestic farm animals; pets; wildlife and fish.
d. Contamination of water and soil.
e. Contamination of crops.

General

Regardless of the disposal plan you follow, you can lessen the degree of hazard by -

a. N.A.C.A. one trip container disposal method:
    1. Empty container into spray tank. Then drain in vertical position for 30 seconds.
    2. Add a measured amount of rinse water (or other diluent) so container is 1/4 to 1/5 full. For example, one quart in a one-gallon container.
    3. Rinse container thoroughly, pour into tank, and drain 30 seconds. Repeat three times. Add enough fluid to bring tank up to level.
    4. Crush pesticide container immediately. Sell as scrap for recycling or bury. Do not reuse.
b. Keeping all empty containers in a secure storage area until they can be disposed of safely.
c. Large metal drums (30-50 gallon sizes) can be disposed of most safely and easily by returning them to the supplier or selling them to a cooperage firm equipped to handle drums contaminated with toxic materials.
d. Disposing of unlabeled containers and their contents.
e. Completely emptying the contents and, if possible, burying the unused chemical at least 18 inches deep in an isolated location away from water supplies.
f. Never stand in the smoke or fumes of burning containers or pesticides.
g. Never dispose of aerosol containers in a fire; they will explode.
h. Never burn hormone type herbicides (such as 2,4-D, etc.) or their containers. Fumes and smoke from these may damage crops for great distances.
i. Never burn herbicides or defoliants containing chlorates as they will explode when heated.

Combustible Containers (paper, cardboard, plastic)

a. Burn empty containers completely (except those referred to above).
b. Caution: Some municipalities have restrictions against burning. Consult local authorities before burning containers. If burning is not permitted in your area, it would be best to store such containers under lock and key until enough of them are collected to make it practical to transport them to a sanitary land fill where their burial can be insured.

ENVIRONMENT

Pesticides and the Environment

A pesticide is useful to man because it is poisonous to some form of plant or animal life. The plant or animal against which the pesticide is directed is called the target species. Other plants or animals are called non-target species. For example, in controlling a broad-leaf weed in a bluegrass fairway, the broad-leaf weed is the target species and the bluegrass is the non-target species. If the action of a pesticide could be confined to the target species there would be few environmental problems, but sometimes a pesticide has a direct effect on a non-target species and may kill it. In the above example if the pesticide used to control the broad-leaf weed is not applied correctly it could also kill the bluegrass.

Non-target plant and animal species may be poisoned by a pesticide directed toward a target species in several ways. They may be killed by being directly exposed to the pesticide or the pesticide may be carried by wind, water, etc, to the non-target species. An example would be the spray drift from a fairway herbicide application onto desirable ornamental plants growing near the fairway.

A non-target species may be killed by "secondary poisoning". In this case a non-target species eats enough of the poisoned target species to become poisoned.

Another way is by "biological concentration". A non-target species over a period of time eats enough of any species (target or non-target) containing small amounts of poison. The poison then tends to concentrate and may develop a concentration high enough to kill it.

Movement of Pesticides

Many pesticides often become attached to soil particles and when erosion by wind or rain occurs the pesticide is carried along with the soil particle. Some pesticides are not strongly attached to soil particles and may be leached down through the various soil layers. In either case it is possible for the pesticide to reach a water source and to be picked up by fish or other aquatic life.

Most pesticides that become attached to soil particles stay near the point of application. Here bacteria and other soil organisms aid in breaking them down into other less harmful chemicals.

Pesticides themselves may travel through the air as a vapor or as spray drift. Many pesticides have the property of changing into a vapor or gas at ordinary temperatures when exposed to air. Such chemicals are said to be volatile. Herbicides such as 2,4-D ester are highly volatile and the vapors may be carried away from the target area by wind. This could result in injury or death to desirable non-target vegetation.

Any pesticide carried by the wind can be "washed" out of the air by rain, thus returning it to the soil. Plants may then pick up the pesticide, and animals may eat the plants. In this way pesticides may be found in plants and animals far removed from the application site.

Some pesticides may be changed under the influence of light. This process is known as "photodecomposition." The effectiveness of chlordane, for example, is decreased when exposed to light. This is one reason why it should be "watered in" after application.

Persistence of Pesticides

All pesticides degrade or break down into less harmful chemicals eventually. This process occurs at different rates for different pesticides. Environmental factors such as light, temperature, water, etc, have an effect on the breakdown of pesticides. Those that break down in a few hours or even a few days after application are of less concern environmentally than those that persist for a longer period.

The environmental difficulty with persistent pesticides is that they remain in their original chemical form or a breakdown product and can, in time, move throughout the environment. This means that the persistent pesticide may end up being concentrated in a non-target plant or animal somewhat removed from its point of application.

In summary, the fate of a pesticide in the environment may be as follows:

1. Pesticide applied
    a. May spread as drift
2. Reaches soil surface
    a. May volatilize
    b. May undergo photodecomposition
    c. May spread with surface runoff
3. Moves into soil
    a. May leach out of soil
    b. May be degraded by microorganisms
    c. May be diluted by soil water
    d. May be attached to soil particles or organic matter
    e. May react with other chemicals in the soil
4. Absorbed by plants
    a. May spread with grass clippings

When making a decision regarding the use of a pesticide, keep in mind what the total effect of that pesticide could be. Consider what, if any, non-target plants or animals might also be affected. Consider the possible danger from spray drift or volatilization. Only after careful consideration and planning should you apply a pesticide.

APPLICATION EQUIPMENT

The pesticide application equipment you use is important to the success of your pest control job. You must first select the right kind of equipment. Then you must use it correctly to suit your needs and take good care of it. Here are some things you should know about choosing, using, and caring for equipment.

Sprayers

Hand Sprayers

Hand sprayers are for small jobs around the farm and home. You can use them in restricted areas where a power sprayer would not work.

Advantages:

a. economical
b. simple
c. easy to use, clean, and store

Limitations:

a. may give an uneven application rate because of hand operation
b. lack agitation and screening for using wettable powder formulations. You must shake the sprayer often to provide agitation.

Low Pressure Field Sprayers

Most of these sprayers are used for treating field and forage crops, pastures, and fence rows. They also may be used to apply fertilizer-pesticide mixtures.

Advantages:

a. medium to large tanks
b. low cost
c. light weight
d. versatility.

Limitations:

a. low gallonage output limits their use when high volume is needed
b. low pressure limits pesticide penetration
c. agitation is limited

High Pressure Sprayers

These are often called hydraulic sprayers. They are designed to deliver high volumes (100 or more gallons per acre) at high pressure (above 100 psi). They are used to spray fruits, vegetables, landscape plants, and livestock.

Advantages:

a. well built
b. usually have mechanical agitation
c. durable

Limitations:

- a. high cost
- b. large amounts of water, power, and fuel needed
- c. high tire loads
- d. high pressure which makes a spray that drifts easily

Air Blast Sprayers

These units use a high speed airstream to break up the nozzle output into fine drops which move with the airstream to the target. The air is directed to either one or both sides as the sprayer moves forward.

Advantages:

- a. good coverage and penetration
- b. low pump pressures
- c. mechanical agitation

Limitations:

- a. drift hazards
- b. chance of overdosages
- c. difficult to use in small areas
- d. hard to confine spray discharge to specific target

Ultra Low Volume (ULV) Sprayers

Deliver undiluted special pesticide formulations. High speed airstreams may be used to break up and direct the spray.

Advantages:

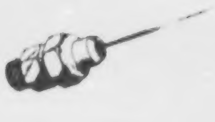
- a. no water is needed
- b. equal control with less pesticide

Limitations:

- a. does not provide for thorough wetting
- b. hazards of using high concentrates
- c. chance of overdosage
- d. small number of pesticides that can be used this way

Nozzles

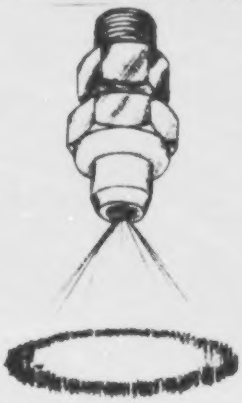
There are five basic nozzle types. All other types are variations. They are - Solid Stream, Cone, Broadcast, Flat, Flooding Nozzle.

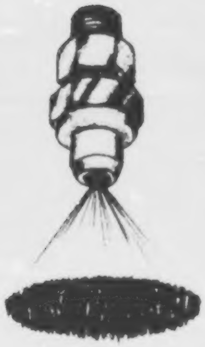


Solid Stream - A single jet used in handguns to spray a distant target or fixed in a nozzle body to apply a narrow band or to inject into the soil.

Hollow Cone - This nozzle forms a pattern that is circular with tapered edges and little or no spray in the center. It is used for spraying foliage. There are two types of hollow cone nozzles:

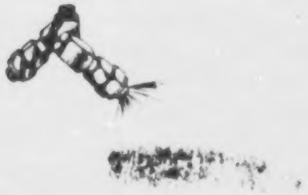
a. the core and disk
b. the whirl chamber





Solid Cone - This nozzle forms a circular pattern. The spray is well-distributed throughout the pattern. It is used for spraying foliage.

Broadcast - This nozzle forms a wide flat fan pattern. It is used on boomless sprayers and to extend the effective swath width when attached to the end of a boom.



You can get nozzles in many materials. Here are the main features of each kind.

Brass:

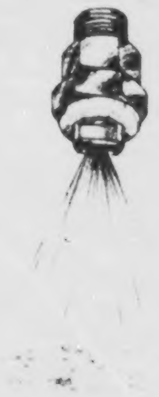
a. Inexpensive
b. Wears quickly from abrasion
c. Probably the best material for limited use

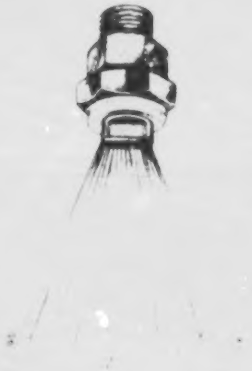
Stainless Steel:

a. Will not corrode
b. Resists abrasion, especially if it is hardened
c. Probably the best material for extensive use

Flat Fan - This type has three different variations:

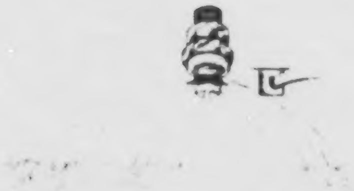
The regular flat fan nozzle makes a narrow oval pattern with lighter edges. It is used on booms for broadcast spraying and is designed to be overlapped 30-50 percent for even distribution.





The even flat fan nozzle makes a uniform pattern across its width. It is used for band spraying and for spraying walls and other surfaces.

The flooding nozzle makes a wide-angle flat spray pattern. It works at lower pressures than the other flat fan nozzles. Its pattern is fairly uniform across its width. It is used for broadcast spraying.



Plastic:

a. Resists corrosion and abrasion
b. Swells when exposed to some solvents

Aluminum:

a. Resists some corrosive materials
b. Is easily corroded by some fertilizers

Tungsten Carbide and Ceramic:

a. Highly resistant to abrasion and corrosion
b. Expensive

Use and Care of Nozzles

Use nozzles of uniform type and size. Nozzle caps should not be over-tightened. Adjust nozzle height and spacing to suit the target. Follow the nozzle manufacturer's instructions and the directions on the pesticide label.

Replace any nozzles having faulty spray patterns.

Check each nozzle for uniform flow using water and a jar marked in ounces. Replace any with flow 5 percent more or less than the average of the nozzles in the system.

Clean nozzles only with a toothbrush or wooden toothpick.

Operation and Maintenance

Always read and follow the operator's manual. It will tell you how to use and care for your sprayer. Always drain and rinse your sprayer after each use. Check for leaks before and during use. Be alert for nozzle patterns.

If nozzles clog or other trouble occurs in the field, shut off the sprayer and move it to the edge of the field before dismounting to correct the problem. Wear protective clothing while making repairs.

Store sprayers properly after use. But first rinse and clean the system. Then fill the tank almost full with clean water. Add a small amount of new light oil to the tank. Coat the system by pumping tank contents out through the nozzles. Drain the pump and plug its openings or fill the pump with light oil or antifreeze. Remove nozzles and nozzle screens and store in light oil or diesel fuel.

Dusters and Granular Applicators

Hand Dusters

Like hand sprayers, hand dusters are used mainly around homes and in gardens. They may consist of a squeeze tube or shaker, a sliding tube, or a fan powered by a hand crank.

Advantage:

a. the pesticide is ready to apply

Limitations:

a. high cost for pesticide
b. hard to get good foliar coverage
c. dust is subject to drifting

Powder Dusters

Power dusters use a powered fan or blower to propel the dust to the target. They range from knapsack types to those mounted on or pulled by tractors.

Advantages:

a. simply built
b. easy to maintain
c. low in cost

Limitations:

a. drift hazards
b. high cost of pesticide
c. application may be less uniform than sprays

Granular Applicators

These include:

1. hand-carried spinning disk types for broadcast coverage
2. mounted equipment for applying bands over the row in row crops
3. mounted or tractor-drawn machines for broadcast coverage

Advantages:

a. eliminates mixing
b. is low in cost
c. minimizes drift

Limitations:

a. high cost for pesticide
b. limited use against some pests because granules won't stick to most plants

Use and Maintenance

Dusters and granular applicators are speed-sensitive, so maintain uniform speed. Do not travel too fast for ground conditions. Bouncing equipment will cause the application rate to vary. Stay out of any dust cloud that may form.

Watch banders to see that band width stays the same. Small height changes due to changing soil conditions may cause rapid changes in band width.

Clean equipment as directed by the operator's manual.

Calibration

Calibration is simply adjusting your equipment to apply the desired rate of pesticide. You need to do this so that you can be sure you are using each pesticide as directed on the label. Too much pesticide is dangerous; too little will not do a good job. Only by calibrating correctly can you safely get the best results.

There are many ways to calibrate equipment. The preferred methods differ according to the kind of equipment used. Your Cooperative Extension agent can show you how to calibrate your equipment. Here is one basic method for sprayers and another for dusters and granular applicators.

Sprayers

To apply a pesticide evenly and accurately, your sprayer must move at a constant speed when in use. It also must be pumping at a constant pressure. Each nozzle must be clean and at the right height. All nozzles must be of the correct type and size. Each nozzle in the system must deliver its rated amount of pesticide.

First, choose the speed, pumping pressure, and nozzles that you want to use. Fill the spray tank with water and operate the sprayer in place to fill the system. Then top off the tank. Spray one acre as if you were applying the pesticide.

Measure the amount of water needed to refill your tank. This is your application rate per acre. If it takes 8 gallons to refill the tank, you are spraying at the rate of 8 gallons per acre. If your sprayer has a tank of more than 10 gallons capacity, spray an area large enough to use at least 10 percent of the tank capacity.

Types of Ground Sprayers

Ground sprayers are used more than any other type of equipment for pesticide applications. Sprayers ranging from small knapsack sprayers to large self-propelled sprayers are discussed below.

Hand Sprayers

These sprayers are used mostly for spot treatments. They are displacement-type sprayers. Air is pumped into a pressurized tank, thereby displacing the spray solution, forcing it out through the nozzle. For constant pressure spraying, CO_2 or compressed air is fed into the spray tank through a regulator valve. Various nozzles can be used to achieve the desired results.

Small General Use Sprayers

These sprayers include the power wheelbarrow sprayer, the "estate" or small wheel-mounted sprayer and the small skid-mounted sprayer. These are designed to handle spraying jobs too large for hand equipment.

Power wheelbarrow sprayers have alternating piston pumps that deliver 1½ to 3 gallons per minute and develop pressures up to 250 psi. Power is supplied by an air-cooled engine or electric motor of 1½ to 3 horsepower. Tank size ranges from 12 to 18 gallons. Spray material in the tank may be mechanically or hydraulically agitated. Standard equipment includes an adjustable hand gun and a hose. Spray booms are available for some models.

Estate sprayers are small two-wheel mounted units equipped with handles for moving. Trailer hitches are available as special equipment. Smaller models have 15 to 30 gallon tanks and pumps that deliver 1½ to 3 gallons per minute at pressures up to 250 psi. Larger models have 50 gallon tanks and pumps that deliver 3 to 4 gallons per minute at pressures up to 400 psi. Power is supplied by a 1½ to 3 horsepower engine. Spray material in the tank is mechanically agitated. Standard equipment includes a hand gun and a hose. Spray booms are available for some models.

General Use or Multi-Purpose Sprayers

These sprayers are designed to handle most of the spraying needs. They may be tractor or truck mounted, pull type or self-propelled. They usually have roller type pumps that limit their pressure to about 80 psi for continuous spraying. Higher pressures cause very rapid pump wear. Centrifugal pumps are available for low pressure spraying where larger volumes are needed. Piston pumps are available for higher pressure spraying. Tank sizes range from 50 gallons upward. The spray material is usually agitated hydraulically. Agitation is often a problem with the larger tanks using the roller or piston pump (see section entitled "Spray Equipment Parts - Agitators").

This type of sprayer is used to apply a wide range of materials including herbicides, insecticides and fertilizers. Good quality materials for the tank, pump and other components are essential to reduce corrosion problems. The general use sprayer is normally equipped with a four or six row boom but special application booms or hand guns may also be used.

High Pressure Sprayers

These sprayers are used primarily for insect control. They provide the high pressure required for breakup and complete coverage of the foliage.

High pressure sprayers are similar in design to multi-purpose sprayers but have piston pumps. The pumps can deliver up to 25 gallons per minute at 400 to 500 psi. All hoses, pressure relief valves, nozzles and valves must be high pressure types. Field booms are designed for specific uses.

Air Blast Sprayers

These sprayers use high-velocity air as a vehicle to transport spray droplets from the point of release to the point of application. High volume fans supply the air which is directed to one or both sides of the sprayer. Nozzles operating at low, moderate or high pressure deliver the spray droplets into the high-velocity air stream. The high speed air aids in breaking up the droplets and transporting these smaller droplets for thorough coverage. Agitation of the spray material in the tank is usually accomplished with a mechanical agitator.

Low Volume Air Sprayers (Mist-Blowers)

A special class of air sprayers has recently emerged which is characterized by the following features:

- --high air velocities (120 to 200 mph) and somewhat lower air volumes than conventional air blast sprayers
- --metering devices, which may or may not be conventional nozzles, that operate at low pressures and depend on the high speed air for liquid breakup
- --application of pesticides using much lower volumes of water than conventional air blast sprayers.

A considerable saving in time and labor is possible with low volume sprayers because less water is handled. However, their calibration is more critical, favorable weather for spraying is more essential, and coverage with very low volumes may be less satisfactory than with normal volumes delivered by conventional air blast sprayers.

Ultra Low Volume Sprayers (ULV)

Ultra low volume (ULV) spraying is accomplished by spraying the chemical concentrate directly without the use of water or any other liquid carrier. Many ULV ground sprayers use a fan which delivers high speed air to help break up and transport the spray. The main advantage of ULV sprayers is the labor and time saved due to the elimination of water. The main disadvantages are increased risk from spraying the concentrate, and the fact that only a limited number of pesticides have been cleared for ULV application.

Spray Equipment Parts

To do a proper job of applying pesticides an operator must have the correct equipment and operate it correctly. Selection of a good quality sprayer will depend on carefully selecting each of the following parts:

Tanks

Tanks should be made of rust-resistant steel, fiberglass or polyethylene to avoid or reduce rust, sediment, plugging and restriction problems. Tanks from 55 to 150 gallons or larger are available on mounted sprayers and 200 gallons or larger on pull-type sprayers. Only one tank per spray rig is recommended as more than one tank makes agitation difficult. Tanks need a large covered opening in the top with a removable strainer to make filling, inspection and cleaning easy. A drain plug in the bottom is necessary for complete drainage when cleaning.

Pumps

The pump is the heart of the sprayer. It must have a pumping capacity of sufficient volume to supply the nozzles and hydraulic agitator (if one is used) and to maintain the desired pressure at full capacity. The pump parts must be able to withstand the corrosive and abrasive effects of the spray materials and have a reasonable life expectancy. When wettable powders are used the resistance of the pump to wear is very important. A pump that is subjected to moderate wear such as a roller pump should be sized to provide a reserve capacity about 50% greater than needed for the nozzles and agitator. This reserve capacity will extend the life of the pump.

The pump will be damaged if operated dry, or with a restricted inlet. Dry operation can occur when the pump is operated unprimed. Pump damage from not being primed is reduced when the suction line enters the tank at the bottom. The pump may also be damaged by improper mounting. If the pump is mounted directly on a tractor or truck P.T.O. shaft, do not attempt to bolt it down. A torque bar that extends about 6 inches from the pump is chained to the stationary part of the vehicle to prevent the pump body from rotating. With piston pumps two torque bars should be used. One is chained stationary, and the other is attached to a spring on the opposite side of the pump from the chain to keep the chain tight.

The table on page 77 , "Typical Sprayer Pump Characteristics," lists the capacities, pressure ranges, wear characteristics and other information that can be used to select the proper pump.

Agitators

Agitation is essential for a uniform spray supply rate. Agitation can be accomplished by mechanical or hydraulic means. For large orchard-type and vegetable sprayers a mechanical paddle mounted lengthwise in the botton of the tank and driven by power is the best agitator. Most field sprayers have hydraulic agitation of the by-pass or jet type. The by-pass type uses the return hose from the pressure relief valve to agitate the tank. The by-pass agitator hose must extend to the bottom of the sprayer tank.

By-pass agitation is not sufficient on field sprayers with tanks larger than 55 gallons unless a centrifugal pump is used. Gear, piston and roller pumps require a "jet" agitator on 100-gallon or larger tanks. The "jet" must be located in the bottom of the tank and held in place on a pipe (NEVER ON A HOSE) as shown in the Jet Agitation Location diagram on page 78 . The "jet" agitator must be connected to the pressure side of the sprayer and must operate at the operating pressure of the sprayer. Do not attach jets to the by-pass line. A 55-gallon tank requires one or more jet outlets, 100 to 150 gallon tanks should have a minimum of three outlets, and 200-gallon and larger tanks should have three or more outlets on a manifold horizontally about 1 to 2 inches from the bottom of the tank and allow the jets to discharge horizontally across the bottom of the tank. The tank capacity and operating pressure will determine the minimum jet size.

From the Hydraulic Agitation Requirements Table on page 78 it is evident that for low and medium pressure spraying when the pump limits the jet size at or near the minimum required to maintain agitation, it is desirable to increase the pressure about threefold while mixing a new tank to achieve the proper agitation.

The orifices in the jet agitator must be sized so that the pump can maintain the operating pressure when all the nozzles are operating. In addition, some reserve capacity is needed to compensate for pump and nozzle wear.

Hoses

Hoses should be of neoprene or other oil-resistant materials and strong enough to take peak pressures. Hose test pressure should be twice the operating pressure. The suction hose should be made of 2-ply fabric. It should be larger than the pressure hoses (boom, jet agitator, by-pass, etc.) because it must provide the total pump flow through the suction hose, suction strainer, fittings and valves. The pressure drop in pressure hoses, fittings, valves and strainers should not exceed 10% of the operating pressure. Hose clamps of the worm screw type are best and are required when the operating pressure exceeds 100 psi. When the pressure exceeds 300 psi, use two worm screw clamps or other special clamps.

Normal Permissible Flow Rates for Hoses

Hose Size (inches)	3/8	1/2	5/8	3/4	1	1¼
Maximum Flow (GPM)	2	4	8	12	20	40

Strainers

Strainers in sprayers prevent foreign materials from clogging the equipment and from entering and wearing precision parts of the sprayer. There should be a 12 to 25 mesh screen strainer in the filler opening, a 15 to 40 mesh screen strainer in the suction or supply line to the pump, and a 50 to 100 mesh screen strainer between the pressure relief valve and the boom. Strainers should be 50 mesh or larger for wettable powder applications.

The strainer screen should be large enough to prevent excessive pressure drop and plugging. The suction strainer should have at least two square inches of screen area per gallon per minute of flow. The pressure strainer should have at least one square inch area per gallon per minute of flow.

Pressure Gauges

Pressure gauges are important because pressure affects the amount of spray applied. Use the lowest pressure possible for each job. High pressures use extra power, wear equipment faster and increase drift. Pressure gauges should be handled with care and equipped with a gauge protector when spraying corrosive materials or when using a piston type pump. Select a gauge which can be read accurately at the pressure to be used.

Pressure Regulators

Pressure is regulated with a pressure relief valve that opens when the operating pressure exceeds its setting. For low pressure spraying (10 to 40 psi), a diaphragm pressure relief valve is recommended.

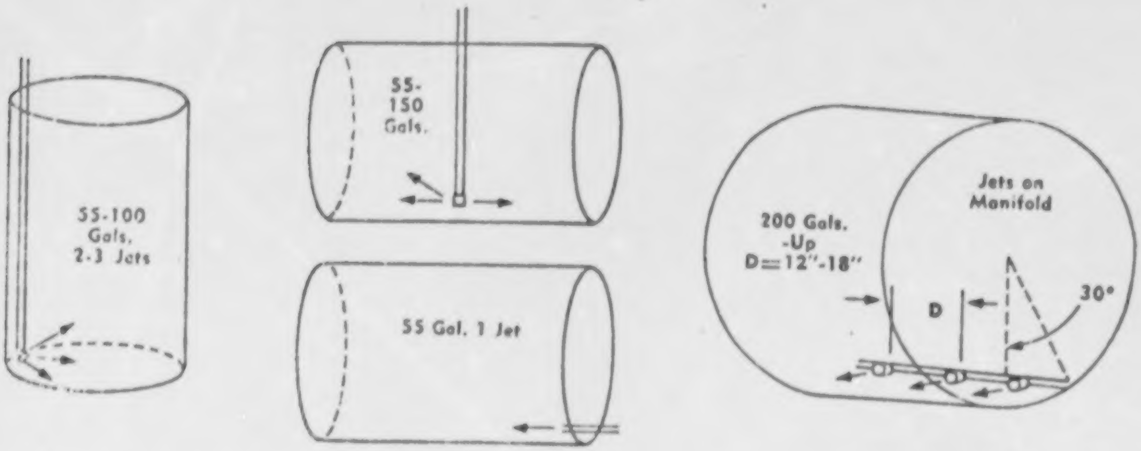
When the desired operating pressure on a sprayer cannot be reached, check the pressure relief valve by observing the flow from the return hose. If there is flow in the return hose before the operating pressure is reached, the relief valve is not seating and must be checked for wear, trash and broken springs. Repair or replace defective relief valves IMMEDIATELY.

When using a centrifugal pump the pressure may be regulated with an adjustable orifice valve (globe or gate valve). This will make the sprayer a constant rate sprayer, independent of ground speed as long as the tractor gear is not changed for a reasonable change in ground speed.

Pump Type	Available Construction Material	Available Port Sizes (inches)	Maximum Practical Pressure psi	Capacity of 3/4 in. Port Pump @ 540 RPM GPM @ 40 psi	Self Priming	Effect of Abrasive Materials	Repairable
External Gear	Bronze or Cast Iron	½ - 1	75	6	Partly	Severe	No
Internal Gear	Cast Iron	3/4	75	6	Partly	Moderate	No
6 Roller	Cast Iron or Ni-resist	3/4 - 1½	75	6 - 8	No	Moderate	Yes
7-8 Roller	Ni-resist, Cast Iron or Bronze	3/4	75	10	No	Moderate	Yes
Centrifugal	Cast Iron	1¼ - 2	50	40*	No	Little	Maybe
Diaphragm	Cast Iron	3/4	75	5	Yes	None	Yes
Piston	Cast Iron and Ceramic	3/4 - 1¼	400	6 - 10	Yes	Little	Yes

* 1¼ in. suction X 1 in. discharge centrifugal pump. PUMP RPM = 3250 at 50 PTO.

JET AGITATION LOCATIONS IN TANKS


55-100
Gals.
2-3 Jets
55-
150
Gals.
55 Gal. 1 Jet
200 Gals.
-Up
D=12"-18"
Jets on
Manifold
D
30°

HYDRAULIC AGITATION REQUIREMENTS

	Minimum Agitation Flow (% Tank Capacity)			
	By-Pass		Jet Agitator	
Operating Pressure	For Initial Mix*	To Maintain Mix*	For Initial Mix*	To Maintain Mix*
10 psi	25%	10%	10%	5%
20 psi	25%	10%	8%	3½%
30 psi	25%	10%	7%	3%
50 psi	25%	10%	6%	2½%
100 psi	25%	10%	5%	2%
200 psi	25%	10%	4%	1½%
400 psi	25%	10%	3%	1%

*For initial mix of wettable powder in approximately 3 minutes

Cut-Off Valves

Cut-off valves are essential on every sprayer. Place a quick-acting valve (or valves) between the pressure regulator and the nozzle to control the flow of spray material. One valve may be used to cut off the entire operation, or a combination of two or three valves may be used to control the flow of individual sections of the boom. If a screw type valve is used it should be a quick-acting "globe" valve. Flow cut-off valves should be easily accessible from the tractor seat.

Nozzles

The nozzle and its adaptation to the spray application requirement is important in the effective use of agricultural chemicals. The nozzle helps control the rate, the uniformity, the thoroughness and the safety of pesticide application.

Select nozzles that will provide the proper particle size and application rate within the recommended range of pressures. The spray pattern and nozzle location should provide excellent coverage of the target area but allow little spray to escape to other areas. BE SURE THAT ALL NOZZLES ON THE BOOM ARE THE SAME AND THE RECOMMENDED TYPE FOR THE JOB.

To meet various requirements, nozzles are classified by the spray delivery patterns, spray angle, discharge rate and the materials from which they are made. The common nozzle spray pattern types are:

Flat (fan) Spray Nozzle - These are used for broadcast or boom spraying such as weed control work. Drift is less than that with standard cone nozzles. Because the rate tapers at the edges, the nozzles must be overlapped approximately 50% for even distribution.

Even Flat Spray Pattern Nozzle - These are for band spraying and produce a uniform spray pattern throughout. Do not use even spray nozzles for broadcast spraying.

Whirlchamber (non-clog) Nozzle - This nozzle is available as a wide angle 120° hollow cone nozzle that may be used in place of the flat spray nozzle. Clogging is minimized because of design. Less drift occurs due to the lower boom height (due to wide angle) and large droplet size. Uniformity of coverage remains fairly constant with changes in boom height.

Flooding Nozzle - These may be used for applying fertilizer solutions and some herbicides. Flooding nozzles operate at low pressures equal to those of whirlchamber nozzles and have even wider spray patterns (up to 160°). However, the pattern width will vary with pressure and height.

Boomless (or Cluster) Nozzle - These nozzles are used for wide swath spraying and may be only one or a cluster of nozzles. The spray droplet will vary in size. The boomless nozzle does not give as uniform coverage as other types and the spray pattern is more affected by wind than a boom type nozzle. The nozzle is NOT recommended for general use.

Hollow Cone Spray Pattern Nozzle - These nozzles are designed for moderate to high pressures and are used where thorough coverage of crop foliage and very uniform distribution is desired. For abrasive materials (wettable powders) the disc type should be used to reduce wear.

Solid Cone Spray Pattern Nozzle - These are used for hand spraying, spot spraying, and moderate-pressure foliar application of insecticides and growth regulators.

Off Center Spray Pattern Nozzle - This nozzle is available in both flat and cone spray pattern types. They can be used on the end of a boom to increase effective boom swath, but are not recommended for general use.

Nozzle Types and Normal Operating Pressure

The correct operating pressure should be selected for the job. When spraying herbicides, drift is often a problem and the pressure should be as low as possible for the nozzle to operate. Insecticides are normally sprayed with a moderate pressure and fungicides are sprayed at a high pressure to achieve adequate coverage. The following table will assist you in selecting the type of nozzle and operating pressure for various spray jobs.

SPECIFIC APPLICATION NOZZLE TYPES

Weed Control	Insect Control	Disease Control
Flat Fan @ 30 psi	Hollow Cone @ 60 psi	Disc Type Hollow Cone @ 300 psi
Whirl Chamber @ 15 psi	Solid Cone @ 60 psi	
Flooding @ 15 psi	Disc Type Hollow Cone @ 80 psi	

Nozzle Construction

Spray nozzles are made of the following metals for the reasons indicated:

--Brass - most commonly used, relatively inexpensive
--Stainless Steel - non-corrosive, relatively expensive
--Aluminum and Monel - resistant to moderately corrosive materials
--Hardened Tungsten Carbide Tips - used for highly abrasive materials (only available in disc type)
--Plastic - used for non-abrasive materials, corrosion resistant, inexpensive. Not recommended for high pressure.

Granular and Dust Applicators

Granular Equipment

Granular applicators are available for both ground equipment and aircraft spreading. Most granular material, however, is applied with ground equipment. Depending on the pesticide, granules are used to reduce toxicity (safer to handle), for convenience in application, to reduce phytotoxicity to plants, to increase selectivity and in some cases to give better placement of the pesticide.

Granular applicators are either gravity-fed or force-fed types. They can be used to apply pesticides in a band or broadcast. The granules are distributed after they are fed from the hopper by deflecting baffles for band or broadcast, or a centrifugal thrower for broadcast spreading.

Dusters

Dusters are sometimes used to apply insecticides and fungicides. Once very popular, their general use has declined in favor of spraying. The introduction of an electronic charger for dusters has revived some interest in dusting. However, mechanical and electronic charging problems have slowed the adoption of electrically charged dusting.

FUMIGATORS

Fumigators are used to apply fumigants for soil disease and nematode control. Some fumigants are also used to control soil insects and weeds. Fumigators are available for handling non-pressure (low volatile) liquids or pressure-type high volatile liquids which quickly change into a gas upon release. An example of a pressure type fumigant is methyl bromide.

Low Volatile Liquid Fumigators

Low volatile fumigants are handled in open or non-pressurized containers. The fumigators for these fumigants may be gravity or force pressure fed and are designed for row or broadcast application. Most row fumigators are the constant-head gravity type, while broadcast fumigators are force-fed types. The force-fed type requires no agitation and the liquid is delivered into the soil through an injector. Positive displacement piston type applicators are also used for broadcast application, but their accuracy is greatly reduced at high speeds. The more volatile fumigants may vaporize in the suction lines and pump on the intake stroke causing the pump to pump gas instead of liquid.

High Volatile (Gas Type) Fumigators

Highly volatile fumigants, such as methyl bromide, must be handled in closed pressurized containers. The fumigators are designed for force feeding these fumigants from a pressurized tank. The tank is either pre-charged with enough pressure to empty its contents or pressurized gas is fed into the tank during application to displace the fumigant.

The pre-charge tank cylinders are approximately two-thirds filled in order to have room for the pre-charging gas. The fumigant is injected into the soil and covered with plastic to prevent its escaping. While these applicators are referred to as "gas type" the fumigant must remain as a liquid in the tank, pressure lines, manifold and metering devices for accurate application.

Maintenance of Equipment

Sprayers

Unused pesticides should never be left in the sprayer. The sprayer should be thoroughly flushed and washed when each day's use is completed (see section on the disposal of pesticides).

Screens in the sediment chamber and nozzles should be removed and cleaned frequently. In some cases this may have to be done daily. The pump, tank and all fittings should be thoroughly washed several times with a detergent and water after each use. Flush out the tank and then pump clean water through the pump and discharge equipment.

Granular Equipment

Equipment used for the application of dry or granular pesticides should be emptied and cleaned after each use. Flush the equipment with clean water and allow to dry. Store in a dry place to avoid corrosion.

Calibration of Spray Equipment

Chemicals applied as a liquid for pesticide control must be applied with precision. Application of less than the recommended rate may result in ineffective control; application of more than the recommended rate can be costly or may injure the turf. In order to ensure proper control, the application equipment must be carefully calibrated.

Factors Affecting Application Rate

The rate of application of a pesticide will vary with the following factors:

1. Ground speed - Speed is a major variable with equipment that has a constant discharge rate. When calibrating your equipment, select a speed that you can use for all areas you intend to cover.
2. Pressure - Select a pressure consistent with the manufacturer's recommendations. If the pressure is too high, spray drift may result. If it is loo low, you may not get the desired pattern from the nozzles.
3. Type or size of nozzles - Their selection should take into consideration the type of material to be applied and the application area.
4. Density of the liquid - Most nozzles are rated for water. When a liquid heavier than water is used, it will be discharged more slowly than water at the same pressure. The reverse is true for liquids lighter than water. Therefore adjustments may have to be made for the density of the liquid.

Calibration Methods

The first step in calibration is to make sure the sprayer is free from all sediment, rust or trash. Next, check the discharge rate of each nozzle by placing containers of the same size under each nozzle and running the sprayer for a brief period. Measure the contents of each container and find the average. If any nozzle's discharge rate varies more than about 10% from the average, it should be replaced.

Perhaps the most accurate method of calibration is to spray a measured area with water and determine the amount of water used. If the tank is not equipped with a measuring device, a stick calibrated at 5 or 10-gallon intervals could be used.

Example: You have a green you know is 6,000 square feet. You have found that you used 60 gallons of water in covering the green. You are therefore applying 10 gallons per 1,000 sq. ft. when your sprayer is operating at that pressure and you are driving at that speed. If the pesticide to be applied has a rate of application of 2 oz. per 1,000 sq. ft., then you need 2 oz. of the pesticide for each 10 gallons in the sprayer to get the correct application rate.

Calibration of Granular Applicators

Granular chemicals for pesticide control must be applied with precision. Application of less than the recommended rate may result in ineffective control; application of more than the recommended rate can be costly or may injure the turf. In order to ensure proper control the application equipment must be carefully calibrated.

Factors Affecting Application Rate

Most granular applicators use gravity flow with a rotating agitator for metering the granulars through an adjustable orifice. Several factors can cause a variation in the application rate, including the following:

1. Size of the metering orifices
2. Speed of the agitator
3. Ground speed of the applicator
4. Density and size of the granules
5. Humidity
6. Temperature

Many granules may look somewhat alike at first, but there may be a wide variation in the size and density of the particles. A different applicator setting may be necessary for each chemical applied. A setting may even be required for the same chemical formulated by two different manufacturers or in two different batches by the same manufacturer.

Except for the orifice size, the ground speed is the most significant factor affecting the application rate. Equipment should be calibrated at normal application speed (i.e., normal walking speed for hand-powered equipment and normal driving speed for powered applications). Speed may be determined by setting markers 176 feet apart and measuring the time required to pass between them. A running start should be used. To find the speed in miles per hour, divide 120 by the time (in seconds) recorded between the markers. Some examples are:

Time Required to Travel 176.Feet (seconds)	Speed (MPH)
60	2
40	3
30	4
24	5
20	6
17	7

Once the speed has been established, the same speed should be maintained during the application. Because the application rate is directly related to the speed, any variation in speed may cause a variation in the application rate.

Calibration of the Spreader

There are several methods of spreader calibration. Regardless of the method used, the first basic step is the determination of the size of the area to be treated. This information together with the rate of application will give you the total amount of material to be applied on the area. (Example: If a green is 6,000 square feet and you want to apply 20 lbs. of a meterial per 1,000 square feet, then 6 X 20 or 120 lbs. of that material will be needed for the green.)

Some material labels or the instruction sheet for the spreader may indicate which setting will provide the desired application rate. The problem comes when no setting information is available.

One method of determining the correct setting is more or less by trial and error. Fill the spreader with the total amount of material required for the area to be treated. Set the spreader at a low setting and cover the area at that setting. Next, estimate the percentage of material remaining in the spreader. Increase the setting of the spreader in relationship to the percentage of material remaining. The trial and error approach may not be the best method.

A method that produces quicker results involves a first step of measuring out a small area (100 sq. ft.) on a smooth surface. Set the spreader at a setting you feel should be correct. Apply the material evenly over the 100 sq. ft. area. Sweep up the material and weigh it. This will give you the weight of material per 100 sq. ft. Multiply the weight by 10 and you have the amount of material the spreader will apply at that setting for 1,000 sq. ft. For example, if you picked up one pound of material for the 100 sq. ft., then you were applying 10 lbs. per 1,000 sq ft.; increase the setting on the spreader and repeat the procedure. If the desired rate is less than 10 lbs. per 1,000 sq. ft., lower the setting and repeat the procedure. Once you have found the correct setting, make a note of it in your records for future reference.

Some spreaders have attachments that collect the material so you do not have to sweep it up. Simply weigh the contents of the container after you have run it over the 100 sq. ft. area.

It may be necessary to calibrate each of your spreaders for each different material to be used. The spreader opening tends to wear and may necessitate replacement at intervals depending on rate of use.

PESTICIDE APPLICATION

Simply stated, the application process is getting the toxicant to the target. This process usually involves a carrier which may be liquid, dry, or air to transport the pesticide to the intended surface or target. Application ranges from the simple act of wiping a repellent on our skin to the use of very elaborate and expensive application equipment. Many factors affect the ability to place the pesticide on the target in the manner and amount for most effective results and with the least undesirable side effects and at the lowest possible cost. Certainly, the selection and use of equipment is of utmost importance and deserves major emphasis in a topic on pesticide application. However, without proper consideration to formulation, adjuvants and compatibility, successful application is impossible. Successful application must also involve principles of proper timing, pesticide drift control, and basic types of spraying which will be dealt with here.

If we assume that the pesticide applicator has selected the proper pesticide to control the pest, the success of the pesticide application may depend on any one of the following factors.

--Proper formulation
--Spray adjuvants (for liquids)
--Pesticide compatibility (if materials are mixed)
--Keeping accurate application records
--Weather conditions or drift problems at application
--Timing of the pesticide application
--Quality and type of equipment used
--How skillfully the equipment is operated
--How accurately the equipment is calibrated

Types of Spraying

Research determines the rate of pesticide required to control a given pest. It may be further determined, for example, that one-half gallon of the pesticide formulated as a 2 lb. per gallon concentrate when mixed with 50 gallons of water (1 lb. active per acre) and sprayed on one acre will distribute the pesticide and control the pest. One pound (or ½ gallon) of the formulation in 50 gallons of water is *dilute spraying*.

If the pesticide above (½ gallon of the formulation) is mixed with 5 gallons of water and distributed evenly over the one acre, the same results would be obtained. This is called *concentrate* or *low volume* spraying. If the ½ gallon of concentrate (or 1 lb. of technical pesticide) were distributed uniformly on the same area with the same degree of control, this would be *ultra low volume spraying*.

In recent years, air blast sprayers using high velocity air streams have been developed that will uniformly distribute low and ultra low volume sprays. Most conventional air-blast sprayers can apply spray mixtures at 1/6 of the dilute spray volume. Some new machines with special metering pumps can apply mixtures as small as 1/33 of the dilute spray volume.

The advantages of concentrate spraying are:

- --less labor
- --less water
- --less time (less reloading).

The disadvantages of concentrate spraying are:

- --increased operator hazards
- --increased need for more accurate calibration and better sprayer maintenance
- --favorable weather conditions are more essential
- --greater care in selecting formulations for spraying is required.

Timing Pesticide Applications

Timing of pesticide applications is very important. The difference between applying pesticides at the right versus the wrong time may result in either success or failure of the pesticide to control the undesirable organism.

Insecticides that are used to protect plants from insect attack must be applied prior to the attack.
Fungicides must be applied at the proper time to achieve the best results. Fungus spores must be killed before they infect the plant tissue because once they have penetrated the tissue, disease control may be impossible.
Herbicide timing is very important. Some herbicides are effective only on the early stages of weed growth. Some must be present on the soil surface when the weeds emerge from the ground.
Systemic Plant Growth Regulator application timing is very critical. These chemicals have to penetrate and actually become a part of the plant's chemistry before they can do the job.
Fumigants may be applied any time weather conditions permit.
Nematicides are usually applied immediately after diagnosis of a nematode problem has been made.

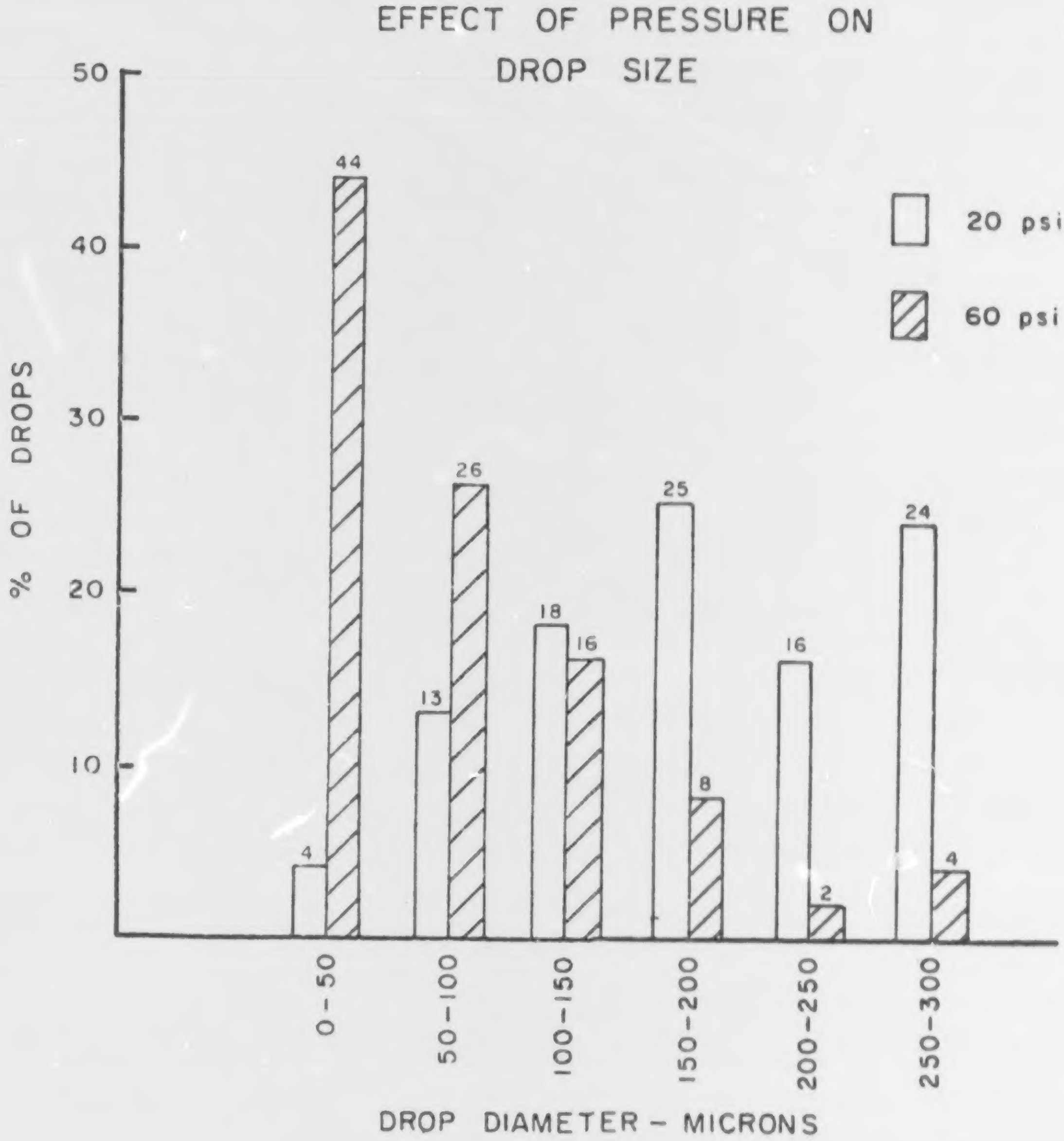
Pesticide Drift

Pesticide drift is the movement of spray, dust particles or chemical vapors from the place of application. It is undesirable because it can injure nearby plants or animals, pollute the environment and even cause injury to man. It also wastes chemicals and may cause uneven distribution.

Spray or Dust Drift

The factors that most influence the movement of particles discharged from application equipment are weather and particle size. Generally, pesticides should not be applied when the wind is blowing faster than eight miles per hour.

Both the pressure and the nozzle size influence the size of the droplet. Smaller droplets tend to drift more than larger droplets. Higher pressures produce a high percentage of small droplets. The higher velocity associated with high pressure also causes more turbulence and less effective coverage. Use as low a pressure as possible to get coverage.


EFFECT OF PRESSURE ON DROP SIZE
50
40
30
20
10
% OF DROPS
20 psi
60 psi
44
4
26
13
18
16
25
8
16
2
24
4
0-50
50-100
100-150
150-200
200-250
250-300
DROP DIAMETER - MICRONS

The smaller the nozzle opening, the more pressure is required and thus a higher percentage of small droplets is produced. Use as large a nozzle opening as possible.

Vapor Drift

Vapor drift, unlike spray or dust drift, is related directly to the chemical properties of the chemical. Many volatile pesticides (ester formulations of phenoxy herbicides) may volatilize and drift under high temperature conditions. Amine or acid formulations should be used where vapor drift could cause problems.

AREA MEASUREMENT

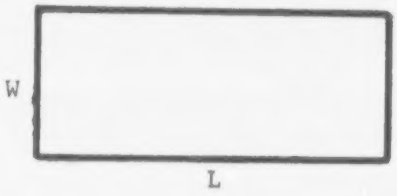
In order to apply a pesticide at the proper rate, the area to be treated must be accurately determined. The unit of area for greens and tees has been 1,000 square feet and for fairways, the acre.

Under the metric system the square meter (1 sq. meter = 10.7 sq. ft.) may be used for greens and tees while the hectare (1hectare = 2.47 acres) may be used for fairways.

There are several methods that may be used to measure areas in the field or from a map.

The first method involves the division of the area to be measured into geometric figures such as rectangles, trapezoids, circles and triangles.

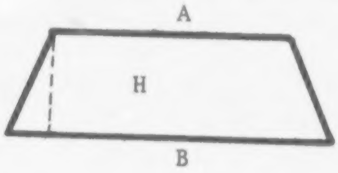
a. Rectangle: The area of a rectangle is found by multiplying the length by the width.



Area = L x W

Example: L = 100 ft. (30.48 meters)
W = 50 ft. (15.24 meters)
Area = 100 ft. (30.48 meters) x 50 ft. (15.24 meters)
= 5,000 sq. ft. (464.5 sq. meters)

b. Trapezoid: A trapezoid is a four-sided figure with two sides parallel. The area is found by multiplying the average length of the parallel sides by the height.



$$\text{Area} = \frac{a + b}{2} \times h$$

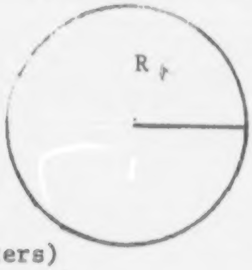
Example: a = 200 ft. (60.98 meters)
b = 300 ft. (91.44 meters)
h = 50 ft. (15.24 meters)

$$\text{Area} = \frac{200 \text{ ft. } (60.98 \text{ meters}) + 300 \text{ ft. } (91.44 \text{ meters}) \times 50 \text{ ft. } (15.24 \text{ meters})}{2}$$

$$= \frac{500 \text{ ft. } (152.42 \text{ meters})}{2} \times 50 \text{ ft. } (15.24 \text{ meters})$$

=250 ft. (76.21 meters) x 50 ft. (15.24 meters)
=12,500 sq. ft. (1,161.4 sq. meters)

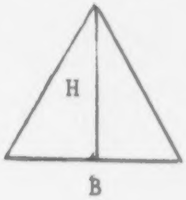
c. Circle: The area of a circle is the radius (one-half the diameter) squared and then multiplied by 3.14 (π).



Area = πR^2

Example: R= 100 ft. (30.48 meters)
Area = 3.14 x 100^2 ft. (30.48^2 meters)
= 31,400 sq. ft. (2,917.1 sq. meters)

d. Triangle: The area of a triangle is one-half the base multiplied by the height.



Area = $\frac{b \times h}{2}$

Example: b = 200 ft. (60.98 meters)

h = 400 ft. (121.96)

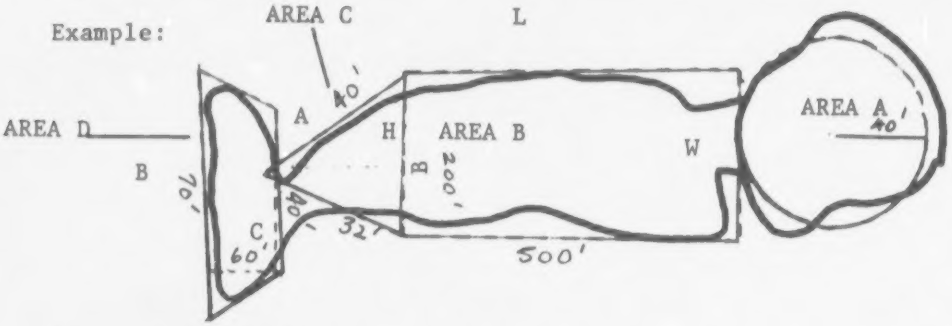
Area = $\frac{\text{200 ft. (60.98 meters) x 400 ft. (121.96 meters)}}{2}$

= $\frac{\text{80,000 sq. ft. (7,442 sq. meters)}}{2}$

= 40,000 sq. ft. (3,721 sq. meters)

Any irregularly shaped turf area can be reduced to one or more of the geometric figures shown above. The area of each is calculated and added together to obtain the total area.

Example:



Area A is a circle.
Area = πR^2
R = 40 ft. (12.2 meters)
Area = 3.14 x 40^2 ft. (12.2^2 meters)
= 5,024 sq. ft. (467.2 sq. meters)

Area B is a rectangle.

Area = L x W

L = 500 ft. (152.4 meters)

W = 200 ft. (61.0 meters)

Area = 500 ft. (152.4 meters) x 200 ft. (61.0 meters)

= 100,000 sq. ft. (9,296.4 sq. meters)

$$= \frac{100{,}000 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./acre}} \quad \text{or} \quad \frac{9{,}296.4 \text{ sq. meters}}{10{,}000 \text{ sq. meters/hectare}}$$

= 2.3 acres or 0.93 hectares

Area C is a triangle.

Area = ½ h x b

h = 32 ft. (9.7 meters)

b = 200 ft. (61.0 meters)

$$\text{Area} = \frac{32 \text{ ft. } (9.7 \text{ meters})}{2} \times 200 \text{ ft. } (61.0 \text{ meters})$$

= 16 ft. (4.9 meters) x 200 ft. (61.0 meters)

= 3,200 sq. ft. (298.9 sq. meters)

Area D is a trapezoid.

$$\text{Area} = \frac{a + b}{2} \times h$$

a = 40 ft. (12.2 meters)

b = 70 ft. (21.4 meters)

c = 60 ft. (18.3 meters)

$$\text{Area} = \frac{40 \text{ ft. } (12.2 \text{ meters}) + 70 \text{ ft. } (21.4 \text{ meters})}{2} \times 60 \text{ ft. } (18.3 \text{ meters})$$

$$= \frac{110 \text{ ft. } (33.6 \text{ meters})}{2} \times 60 \text{ ft. } (18.3 \text{ meters})$$

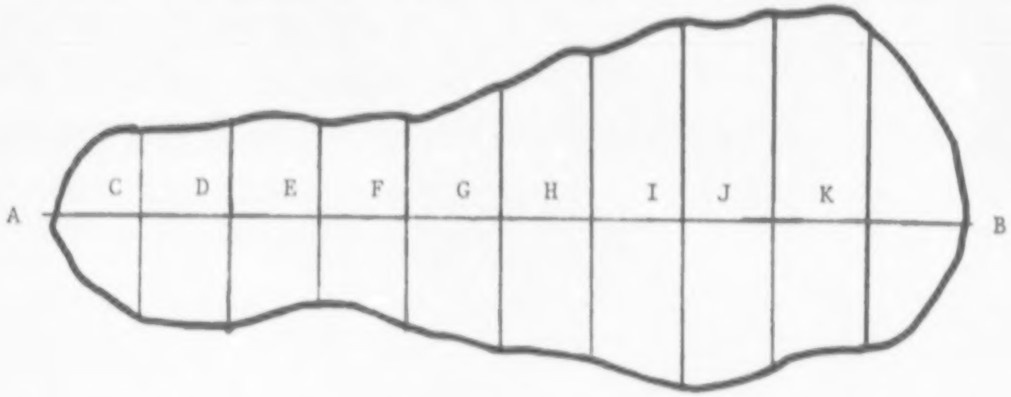
= 3,300 sq. ft. or 307.4 sq. meters

The total area is then A + B + C + D:

	sq. ft.	sq. meters
Area A	5,024	467.2
Area B	100,000	9,296.4
Area C	3,200	298.9
Area D	3,300	307.4
Total	111,524	10,369.9

Another method that may be used to determine the size of an area is the use of offsets from straight lines.

Irregular areas can be reduced to a series of trapezoids by right angle (90^{o}) offsets from points at regular intervals along a measured line.



In using the offset method, first establish points A and B as in the example. Next, measure the distance between A and B.

The irregularity of the area must be considered when determining the number of offsets to use. Uniform areas will require fewer offsets than those that are not uniform. The more offsets used, the more accurately the area will be measured.

Example: If you are going to determine the area of a fairway 300 yards (900 ft) long you may want an offset every 30 yards if the shape of the fairway is fairly regular. If it is irregular you may use offsets every 15 yards (45 ft.). The offsets must be at regular intervals (i.e., offset line C must be the same distance from offset line D as D is from E, E from F, and so on).

In our example fairway we found point A to be 300 yards from point B. The shape of the fairway is fairly uniform so we decided to use an offset every 30 yards (lines C through D).

The lengths of the offset lines (measured from one edge of the fairway to the other) were found to be as follows:

C = 20 yds. D = 25 yds. E = 25 yds. F = 30 yds. G = 40 yds.
H = 50 yds. I = 60 yds. J = 70 yds. K = 65 yds.

Add up the lengths of all the offset lines and multiply by the distance (on line A-B) between them. In our example the total length of all offset lines is 385 yards. The distance between offsets is 30 yards.

30 yds. x 385 yds. = 11,550 sq. yds.

In acres the fairway would be:

$$\frac{11{,}550 \text{ sq. yds.}}{4{,}840 \text{ sq. yds./acre}} = 2.4 \text{ acres}$$

In square feet:

11,550 sq. yds. x 9 sq. ft./sq. yd. = 103,950 sq. ft.

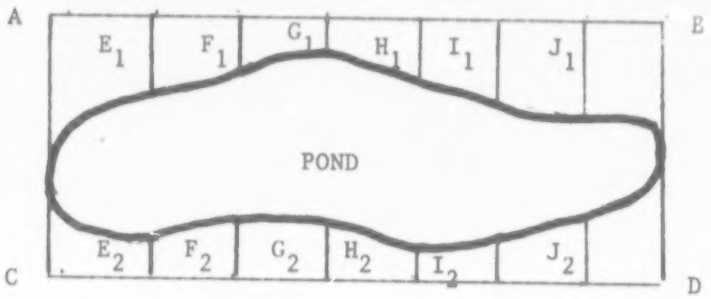
In square meters:

11,550 sq. yds. x 0.83 sq. meter/sq. yd. = 9,586.5 sq. meters

In hectares:

$$\frac{9{,}586.5 \text{ sq. meters}}{10{,}000 \text{ sq. meters/hectare}} = 0.96 \text{ hectares}$$

Ponds may be measured using a variation of the offset method.



The first step is to construct a rectangle (points A,B,C and D). The distance between A and B should be the same as between C and D. The distance between A and C should be the same as between B and D.

The offset lines are measured from the two outside lines to the edge of the pond. You will have two measurements for each offset line (E_1 and E_2, F_1 and F_2 etc.). Each set ($E_1 + E_2$, etc.) subtracted from the A-C distance will provide the distance across the pond at that point.

Example: Length of A to B or C to D = 70 ft.
Length of A to C or B to D = 50 ft.

The total area inside the rectangle is:

70 ft. x 50 ft. = 3,500 sq. ft.

The following measurements were taken:

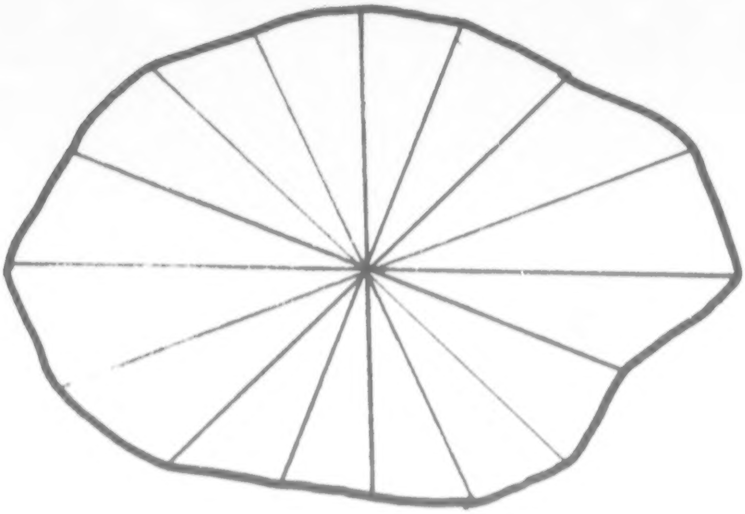
E_1=14 ft.	F_1=8 ft.	G_1=7 ft.	H_1=10 ft.	I_1=14 ft.	J_1=17 ft.
E_2= 6 ft.	F_2=4 ft.	G_2=8 ft.	H_2= 4 ft.	I_2= 4 ft.	J_2= 6 ft.
20 ft.	12 ft.	15 ft.	14 ft.	18 ft.	23 ft.

Total offset		
E = 20 ft.	50 ft. (distance from A to C) - 20 ft.	= 30 ft.
F = 12 ft.	50 ft. - 12 ft.	= 38 ft.
G = 15 ft.	50 ft. - 15 ft.	= 35 ft.
H = 14 ft.	50 ft. - 14 ft.	= 36 ft.
I = 18 ft.	50 ft. - 18 ft.	= 32 ft.
J = 23 ft.	50 ft. - 23 ft.	= 27 ft.
	Total of all offsets	=198 ft.

Total of all offsets (198 ft.) x 10 ft. (distance between offsets)=1,980 sq. ft.
The pond is 1,980 sq. ft.
or in square meters, $\frac{1{,}980 \text{ sq. ft}}{10.76 \text{ sq. ft./sq. meter}}$ = 184 sq. meters

A method for measuring greens has been devised by Mr. Palmer Maples, Jr., CGCS. In his method an irregularly shaped green is converted into a circle by determining the average radius of the green.

From a center point on the green, distances to the edge of the green are measured in 10° increments. From the average of the 36 measurements the area is calculated from the formula of a circle (Area = πR^2).



Example: Total measurements (36) = 1,731.6 ft.

$$\frac{1{,}731.6 \text{ ft.}}{36} = 48.1 \text{ ft. (average radius)}$$

$$\text{Area} = 3.14 \times 48.1^2$$

$$= 7{,}264.8 \text{ sq. ft.}$$

or in sq. meters, $\frac{7{,}264.8 \text{ sq. ft.}}{10.76 \text{ sq. ft./sq. meter}}$ = 6,751.6 sq. meters

The area of the collar may be determined by extending the 36 measurements to the outer edge of the collar. Calculate the entire collar-green area and then subtract from it the area of the green.

Application Calculations

Most pesticide application rates are given as the amount of the active ingredient per 1000 sq. ft. or per acre.

Example I: If an insecticide contains 4 lbs. of active ingredient per gallon and the recommended rate of application is 1 lb. of active ingredient per acre, how much would be needed (in ozs.) to treat 20,000 sq. ft.?

If one gallon of the insecticide contains 4 lbs. of active ingredient than one gallon can be used to treat 4 acres at the rate of 1 lb. active ingredient per acre.

1 gallon = 4 lbs. of active ingredient
¼ gallon = 1 lb. of active ingredient

The next step is to convert gallons to ounces. There are 128 ozs. per gallon, so ¼ gallon = 32 ozs. Thirty-two ozs. of the insecticide would contain 1 lb. of active ingredient and would treat one acre.

Next, determine what percent of an acre is 20,000 sq. ft.

$$\frac{20{,}000}{43{,}560} = 46\%$$

Since 32 oz. of the insecticide will treat one acre and the area to be treated (20,000 sq. ft.) is 46% of an acre, than 46% of 32 ozs. will treat the area at the recommended rate.

.46 (46%) x 32 ozs. = 14.7 ozs.

14.7 ozs. of the insecticide will treat 20,000 sq. ft. at the rate of 1 lb. of active ingredient per acre.

Example II. The label on a liquid pesticide indicates a 10% concentration of the active ingredient. The recommended rate of application is 2 oz. of active ingredient per 1000 sq. ft. How much of the pesticide will it take to treat a 6000 sq. ft. green?

Since the pesticide is only 10% active this means that the rate of application for the pesticide must be 10 times ($\frac{100\%}{10\%} = 10$) the rate for the active ingredient.

2 oz. a.i./1000 sq. ft. x 10 = 20 oz. of total pesticide per 1000 sq. ft.
Green is 6000 sq. ft. so 6 x 20 oz. = 120 oz. of pesticide required.

Example III. A pesticide is labeled as a 75% wettable powder. The rate of application is 10 lbs. active ingredient per acre. How much of the pesticide is required for 3 acres?

First, find how much of the pesticide is needed to get 10 lbs. of the active ingredient. Since it is 75% active, divide 75 into 100.

$$\frac{100\%}{75\%} = 1.3$$

1.3 x 10 lbs. a.i./acre= 13 lbs of the pesticide will contain 10 lbs. of active ingredient

There are 3 acres to treat, so 3 x 13 lbs. = 3.9 lbs. needed

Example IV. Using the following information, which pesticide is a "better buy"?

Pesticide A	Pesticide B
$1.45/lb.	$8.90/lb.
Rate: 8 oz./1000 sq. ft.	Rate: 1 oz./1000 sq. ft.

Since there are 16 oz. in a lb., Pesticide A costs $\frac{\$1.45}{16} = \$.09/\text{oz.}$

and Pesticide B costs $\frac{\$8.90}{16} = \$.56/\text{oz.}$

Pesticide A is cheaper per ounce but the rate of application is eight times that of Pesticide B. It will therefore cost 8 x $.09 or $.72 per 1000 sq. ft. to use Pesticide A compared to $.56 per 1000 sq. ft. to use Pesticide B. Pesticide B is the "better buy."

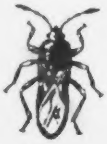
Insect Pests of Turf Grass

Turf grass is suseptible to injury by a number of insects and other pests. The damage may be cosmetic, of serious physiological consequence or simply a nuisance situation. Proper and judicial use of chemical control coupled with sound turf management can keep serious problems at a minimum. To control a pest you should know the pest and its biology and the seasonal development of the organism.

For the sake of clarity, turf pests will be grouped into two groups: above ground, and subterranean.

Above ground pests:

CHINCH BUGS



Chinch bugs are small, white and black insects that suck sap from grass. They may occur in large numbers and remain unnoticed for some time.

Life Cycle

Spring. The overwintering adults emerge and move to the rapidly growing grass plants. The adults feed and begin mating. The females lay about 200 eggs over a 3 to 5 week period. The young bugs (nymphs) begin feeding on the grass within 2 weeks. Summer. The nymphs molt about 5 times to become adults. They continue to feed on the plant sap. The adults in the summer produce a second generation of bugs. Fall. Adults of the second generation hide in grass clumps and leaf litter to spend the winter. When the weather warms in the spring they leave hibernation and search for food.

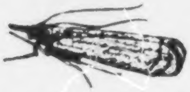
Damage

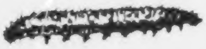
Most of the damage is caused by the nymphs as they suck plant juices from young grass. An infestation of chinch bugs shows up as yellow patches in the lawn or turf. The injured grass turns yellow, then brown as feeding continues. The chinch bugs concentrate their feeding at the edge of the dead patch on the healthy grass.

Test for Presence

Cut both ends out of a large tin can. At the edge of an infested or yellow area in the grass, push one end of the can into the soil. Fill the can with water (keep full) and look for chinch bugs floating to the surface.

SOD WEBWORMS





Sod webworms are the larval or caterpillar stage of several species of Lepidoptera. The adults are commonly seen flying in jerky, short flights from place to place as you walk through the grass. They are often seen near lights at night. Although there are several species of sod webworms, they all do similar damage.

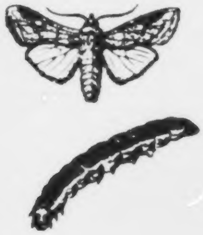
Life Cycle

Spring. When the weather warms, the overwintering caterpillars resume feeding on the grass. Soon the webworm caterpillar is full-grown. Then it forms a pupa. Summer. Adults for only a short period, time to mate and lay eggs in the grass. The caterpillars build silken tunnels at the ground level or in thatch layer. They come out at night to feed on the blades of grass. The caterpillars often cut off a piece of grass and return to their tunnel to eat. There may be two generations during the summer. Fall. The second generation of caterpillars remain in their tunnels in hibernation during the winter.

Damage

Sod webworms seem to prefer new lawns, attacking both cool and warm season turfgrasses, bentgrass, bluegrass, fescue, etc. Damage first appears as small brown areas in the grass. The turf often has a ragged appearance.

CUTWORMS



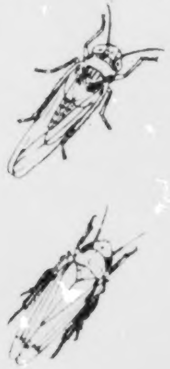
Cutworms are the caterpillars of several species of night-flying moths. The caterpillars feed on the aboveground parts of plants (grain and forage crops, grasses, etc.). They are usually considered pests of crops. But infestations are also common in lawns and turf, especially where these areas border crop land or large untended fields. The caterpillars are capable of migrating from one area to another to feed.

Life Cycle

Spring. The overwintering caterpillars begin feeding when the weather warms. This causes damage to plants early in the growing season. The caterpillars soon become fullgrown and form pupae. Summer. Adults appear in June and July. They fly at night and are attracted to lights. The females lay about 500 eggs (over a 2 to 3 week period) on the lower leaves of grasses. The small caterpillars begin feeding immediately, and may migrate to other areas if there is not enough food. The caterpillars usually hide by day and feed at night. There may be a second generation in the summer. Fall. The caterpillars stop feeding in the fall, and either form pupae or seek shelter in dead leaves on the ground to hibernate. The larvae of both are about 1½ inches in length.

Damage

Cutworm caterpillars can feed on weeds, cultivated plants, and grasses. They infest lawns and feed on grass blades and cut off plants near the soil level. The grass takes on a ragged appearance and may turn brown. Since they feed at night, the caterpillars usually go unnoticed. Like the webworm, these larvae frequently inhabit aerification holes and feed first near these holes.

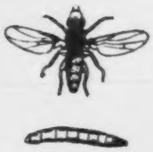


LEAFHOPPERS

Leafhoppers are small, generally pale-colored insects that suck plant sap. They are very abundant and can be found on nearly all species of plants. Adults as well as nymphs feed on plant sap. There may be 2 or more generations a year, and they may become numerous.

Damage

These insects suck the sap from leaves and stems and the plant becomes yellow and spotted. In severe infestations, the lawn or turf appears scorched or wilting from drought. Leafhoppers are only occasionally troublesome on turf.

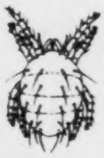


FRIT FLY

The frit fly is a small, blackish fly that is primarily a pest of golf course turf, especially greens. The larvae of this fly feed on the healthy grass stems, causing them to die. The adults do not feed, but are a nuisance to golfers by their presence, often in large numbers. The larvae are not a problem on bermuda grass but can be a serious pest on bentgrasses.

Life Cycle

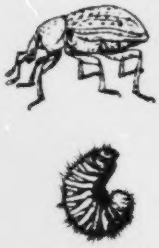
Spring. Adults appear in mid-April and begin mating. Eggs are deposited on the grass stems, close to the ground. Summer. The larvae feed within the grass stem, causing it to turn yellow and die. There may be a second generation in the summer, and further damage. Fall. The fly larvae leave the grass stem to form a pupa in the soil. They overwinter in the resting stage.



MITES

Mites are often numerous enough on lawns that they become a nuisance. They are actually not insects, since they have 8 legs. It is more common to consider mites as household pests. They may seek warm places in and around houses to overwinter. In the spring, they often collect in large numbers on the sides of houses. Mites are very small, usually less than 1/30 of an inch in length.

Subterranean Pests



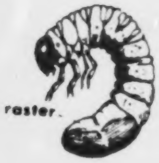
BILLBUGS AND WEEVILS

There are a few species of weevils or billbugs that may infest lawn or turf. The larvae look much like white grubs, except they are smaller and do not have legs. The weevil larvae feed on the roots of grass, and the adult beetles feed on the blades of grass.

Damage

Damage to lawn or turf by the feeding of the larvae of weevils is similar to that of white grubs. The adults eat small holes in the blades of grass. The area around the holes may turn yellow and the grass may have a speckled appearance.

WHITE GRUBS



White grubs are the larval or grub stage of several species of beetles. These beetle larvae are usually C-shaped, and can be found feeding among the roots of grass. They are typically cream-colored with a brown head, and with a dark area at the posterior end where the body contents show through the skin. White grubs feed on grass roots and most complete their development in one year (some May beetles require 2 or 3 years). They are about one inch in length.

Life Cycle (Fig. 2 , page 101)

Summer. Eggs are laid in July and August, the adult beetle selecting the best grass available to deposit the eggs. The young grubs begin feeding on the grass roots within 1 or 2 weeks. Fall. Feeding goes on until fall when the grubs burrow deep into the ground to overwinter. Spring. In the spring, the grubs burrow upwards to the grass root level and resume feeding until late May, when they transform to the pupal stage. Adults begin emerging from the ground about the first week in June or sooner.

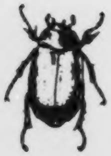
Damage

Evidence of an infestation of white grubs appears as areas of grass begin to turn brown (due to root damage). Usually the turf can be rolled back like a rug to reveal the white grubs.

Identification

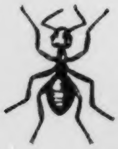
There are several different kinds of beetles included under the term "White Grub". However, they do similar damage and require similar control measures. It is usually not necessary to identify what particular white grub is doing the damage, as chemical control is the same for all.

MAY BEETLE OR JUNE BUG (Phyllophaga spp.)



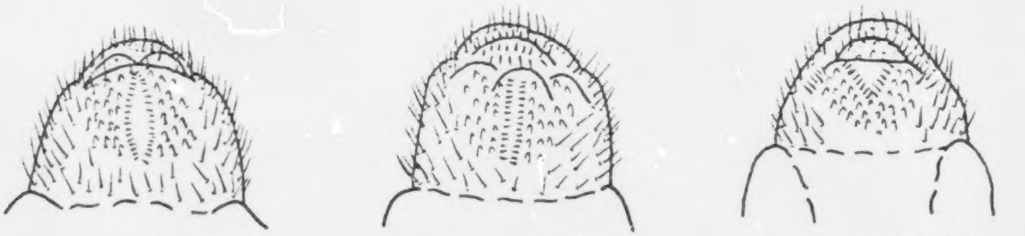
There are over 200 species of these beetles in the U.S. All the adults are brown to nearly black, and range in size from ½" to 1". Most species complete development in a year, although some require 2 or 3 years. The adults are often attracted to lights at night. The grubs are larger than Japanese beetle grubs and are usually abundant in cultivated soils and crop areas. It is the larvae (grubs) that damage turf; the adults are an occasional pest of ornamentals.

ANTS



Ants may become a pest of lawn and turf. Although there are a few different species of ants that may become established in grass, the damage they do and their control are about the same. They may destroy the roots of grasses and become a serious pest.

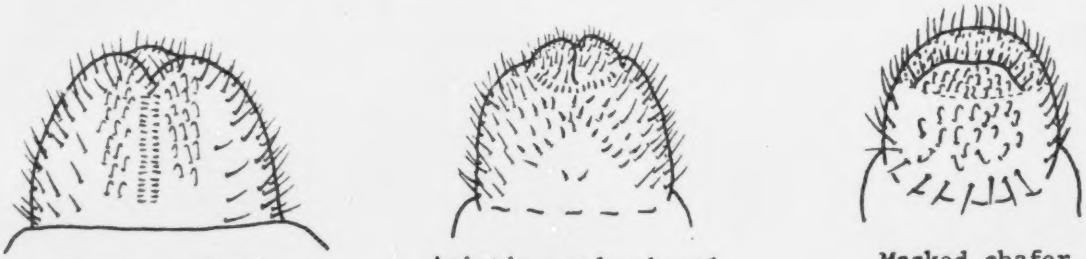
FIG. 1. -- RASTRAL PATTERN OF COMMON WHITE GRUBS



May beetle

Oriental beetle

Japanese beetle



European chafer

Asiatic garden beetle

Masked chafer

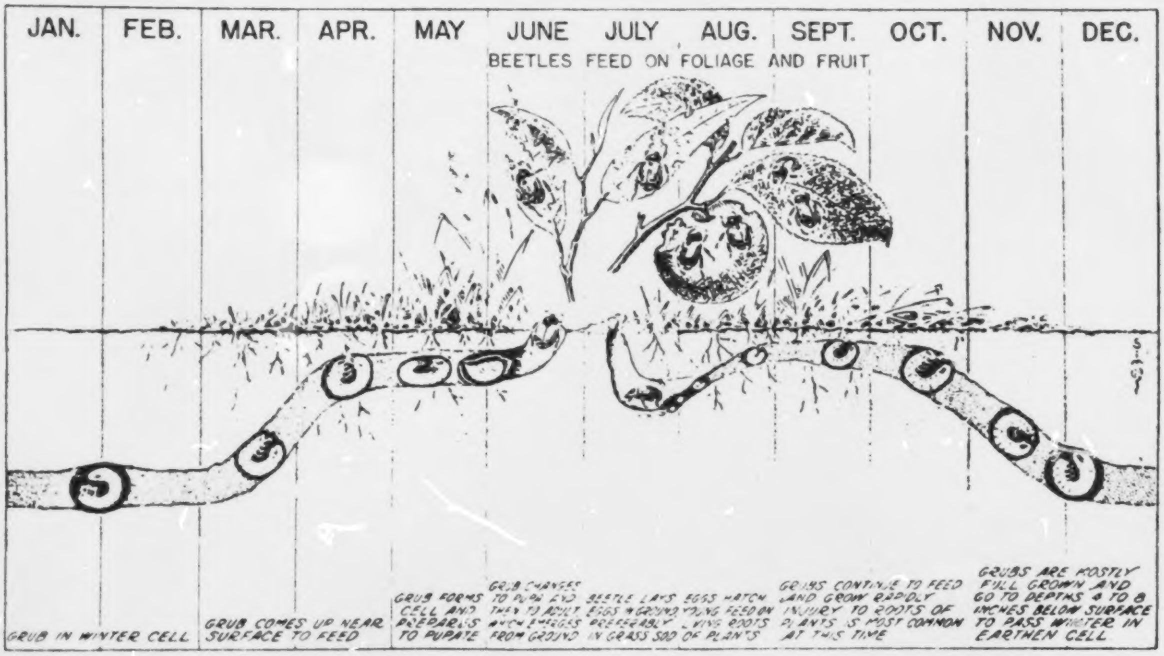

JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
BEETLES FEED ON FOLIAGE AND FRUIT
GRUB IN WINTER CELL
GRUB COMES UP NEAR SURFACE TO FEED
GRUB FORMS CELL AND PREPARES TO PUPATE
GRUB CHANGES TO PUPA AND THEN TO ADULT WHICH EMERGES FROM GROUND
BEETLE LAYS EGGS IN GROUND PREFERABLY IN GRASS SOD
EGGS HATCH YOUNG FEED ON LIVING ROOTS OF PLANTS
GRUBS CONTINUE TO FEED AND GROW RAPIDLY INJURY TO ROOTS OF PLANTS IS MOST COMMON AT THIS TIME
GRUBS ARE MOSTLY FULL GROWN AND GO TO DEPTHS 4 TO 8 INCHES BELOW SURFACE TO PASS WINTER IN EARTHEN CELL

FIG. 2. -- LIFE HISTORY OF COMMON WHITE GRUBS

Damage

Ants construct mounds or small ant-hills, and these act to smother the surrounding grass. Grass may also be killed as the soil around the roots dries out from the effects of extensive tunneling.

BEES AND WASPS

There are some bees and wasps that build their nest in the ground, and occasionally in lawns. The females appear in the spring to form a new nest. They dig holes in the soil and mound up the soil around the entrance.

EARTHWORMS

When earthworms are numerous, they sometimes become pests in lawns. They make small mounds of castings that ruin the appearance of the grass. Earthworms are rarely a serious pest.

SCALE INSECTS

Scale insects suck the juice from grasses; some feed on the crown of the plants and aboveground parts; others feed on the roots. The grass becomes yellow and then brown, and finally dies. Damage is usually more severe in dry periods than in wet.

Several kinds of scales damage lawns in the southern part of the United States, from South Carolina south and west to California. No satisfactory way has been found to control scales on lawns. Consult your county agricultural agent or State agricultural experiment station for current recommendations.

The most important species of scales are the following:

RHODESGRASS SCALE. - The adult is about 1/8 inch in diameter, globular, dark purplish brown, and covered with a white cottony secretion. The tiny nymphs, or crawlers, move about at first and then settle down to feed. They secrete a wax that covers them. The Rhodegrass scale may produce five generations a year.

The adults and nymphs cause lawn damage. They attack chiefly the plant crowns and cause infested plants to turn brown and die.

BERMUDAGRASS SCALE.

The adults are about 1/16 inch long, oval and covered with a white, hard secretion.

This insect infests bermudagrass and is especially active in shady areas. It kills the grass and leaves bare brown patches.

GROUND PEARLS.

The female adult secretes a white waxy sac, in which it places about a hundred pinkish-white eggs. Slender nymphs hatch and feed on the fine grass rootlets. The nymphs cover themselves with hard globular shells that look like tiny pearls. These are called ground pearls. They are about 1/8 inch in diameter.

Ground pearls cause serious damage to bermudagrass in the South and Southwest and to centipedegrass in the South. The grass that they attack turns brown in the summer; it dies in the fall and leaves irregular dead spots.

The following is a partial list of available fungicides and insecticides used on turf and ornamentals.

Fungicides

TURF
Acti-dione
Auragreen
Benlate
Cadminate
Captan
Cleary 3336
Daconil 2787
Dexon
Dithane M-45 (Fore)
Dyrene
Fore
Fungo
Maneb
Maneb + Nickel sulfate
Mertect
Nabam
PCNB
Tersan OM
Thiram
Topsin-M
Zineb

ORNAMENTALS
Acti-Dione
Basic copper sulfate
Benlate
Bordeaux mixture
Botran
Busan-72
Captan
COCS
Cyprex
Daconil 27887
Dexon
Dichlone
Dithane M-45
Dyrene
Ferbam
Fore
Formaldehyde
Karathane
Kocide
Lime sulfur
Maneb
Mertect
Nabam and zinc
Parnon
PCNB
Phaltan (Folpet)
Pipron
Plantvax
PMA
Polyram
Streptomycin
Sulfur
Terrachlor
Terramycin
Terrazole
Thiram
Topsin-M
Zineb
Ziram

Insecticides

TURF
Arsenic Trioxide
Aspon
Baygon
Chlordane
Chlorbenzilate
Dasanit
Delnav
Diazinon
Dibrom
Dursban
Dyfonate
Dylox
Ethion
Heptachlor
Kelthane
Kepone
Lead Arsenate
Lindane
Malathion
Mesurol
Mocap
Nemacur
Nexion
Orthene
Proxol
Pyrethrin
Sevin
Thiodan
Toxaphene
VC - 13

ORNAMENTALS
Arsenic Trioxide
Azodrin
Baytex (Fenthion)
BHC
Bidrin
Chlordane
Chlorobensilate (Acaraben)
Cygon (Dimethoate)
Dasanit
D-D
Diazinon
DDVP
Delnav
Dibrom (Naled)
Dipel
Di-Syston
Dylox
Dursban
Endrin
Ethion
Guthion
Heptachlor
Imidan
Karathane
Kelthane
Kepone
Kryocide
Lannate
Lead Arsenate
Lindane
Malathion
Meta-Systox-R
Metaldehyde
Mesurol
Methoxychlor
Methyl-Parathion
Mocap
Morestan
Nicotine
Orthene
Parathion
Pentac
Petroleum oil-dormant and summer oils
Phosdrin
Pirimor
Plictran
Pyrenone
Pyrethrin
Rotenone
Sevin
Systox
Tedion
Temik
Thimet (Phorate)
Thiodan (Endosulfan)
Thuricide
Toxaphene
Trithion
V-C 13
Vydate
Zectran

NOTE: Before using these or any pesticides be sure to read the label for the manufacturer's recommendations and directions for use.

TURF DISEASES

Turf diseases are most difficult to diagnose. The organisms responsible for losses are microscopic in size and are therefore difficult to see. Problems of diagnosis are compounded by the fact that symptoms will vary considerably with the types of turf and growing conditions.

Major Turf Diseases

Years of research and observation indicate that almost all major turf diseases of Arizona home lawns and recreational areas are caused by fungi. These fungi are capable of attacking the roots, crowns and leaves of grasses, depending upon the specific fungus or grass involved and prevailing environmental conditions.

Four major turf diseases plague homeowners and professional turf managers. These are "melting out" caused by Helminthosporium and Curvularia, "brown patch" caused by Rhizoctonia, "greasy spot or fire ring" caused by Pythium and Fusarium blight caused by Fusarium.

Melting Out: Helminthosporium and Curvularia are responsible for most lawn and and greens problems in the lower elevations of the State. Both fungi are usually found together in diseased turf and probably work in conjunction with one another to cause a serious summer-time disease problem in all types of turf. Some of the names that have been given to the disease caused by these two fungi are melting out, dying out, foot rot, root rot, brown blight, zonate leafspot, summer blight, etc. The disease name "melting out" is preferred because it best fits the observed symptoms in our area.

In Arizona melting out caused by Helminthosporium and Curvularia species is a disease of the leaves and crowns of turf plants and if conditions are right serious damage to the root system may occur. Patches of turf die slowly and have a dried or droughty appearance. These patches have indefinite borders and a melting out effect is observed. These dead areas often have clumps of live grass interspersed but if control is not implemented rapidly they will die also.

Control:

The most important condition contributing to development of this disease is moisture stress on the plant because of improper watering or poor water penetration due to soil compaction. Quite often the disease occurs directly over soil hard pan or compaction areas in your lawn or green. This soil condition prevents penetration of water to the grass root system and the plant is stressed. Helminthosporium and Curvularia prefer weakened plants for attack.

A remedy for this problem is punching holes with a spading fork in these areas showing melting out symptoms. Do not turn the soil; the idea is to create channels for water penetration. In cases involving the Bermuda grasses these areas should be renovated during dormancy in the winter and small amounts of sand added to encourage water penetration and drainage. Golf course superintendents may remedy this problem on Bent grass greens by selective aeration.

The important point is to keep Bermuda turfs growing vigorously during the hot summer months by adequate applications of water and fertilizer. Rapidly growing turf will resist these two fungi.

Brown Patch: Brown patch is a turf disorder caused by the fungus *Rhizoctonia*. Symptoms are often confused with those produced by *Helminthosporium* and *Curvularia* but generally damage is not as severe and the occurrence in home lawns is less frequent. Occurrence in Bent grass golf greens is more frequent. Areas invaded are more circular and have a more defined border than those areas invaded by *Helminthosporium* and *Curvularia*. *Rhizoctonia* thins out areas rather than causing large scale plant loss.

In Bermuda and hybrid Bermuda lawns invaded areas are less well defined than in greens and may be confused with melting out. When a combination of high temperature and high humidity occurs during the summer, the advancing edge of the diseased areas may take on a smoky appearance. This "smoky" coloration is due to the growth of the fungus over the leaf blades when humidity is high and leaves are covered with moisture for long periods of time. This phenomenon is observed only occasionally because of normally low humidity.

Control:

In home lawns avoid heavy nitrogen applications in June. Space applications of nitrogen fertilizer throughout the growing season so that small quantities are applied frequently rather than in only one or two large applications.

Irrigate early in the morning; avoid afternoon and evening waterings.

Removal of excess thatch found in many Bermuda and hybrid Bermuda lawns is also important.

Greasy Spot or Fire Ring: This disease, caused by *Pythium aphanidermatum*, is characterized in Arizona by the appearance of reddish-brown spots with grass blades at the edge appearing "greasy." The term "greasy" comes from the fact that leaf blades turn dark in color, become water soaked, mat together and appear slimy. The disease usually starts as small (approximately 2 inches in size) blotches which may eventually coalesce to form large circular to irregular patches of dead grass. Quite often, especially in Bent grass greens, the centers of these circular areas are not damaged initially and give a doughnut effect. Also, dead grass in the form of streaks often appear and follow low areas where water accumulation has occurred. Injury is most noticeable in early morning when humidity is highest. The bordering edge of a circular spot or group of spots often takes on a reddish coloration. This has led to the term "Fire Ring". Disease development is enhanced by hot humid weather or during a hot spell where excessive irrigation is used or where air circulation is poor over the diseased areas.

Control:

Since abundant moisture is a prerequisite for the development of this disease, overwatering during periods of high temperatures should be avoided. Greens and lawns should be well drained and free from low spots where water may accumulate from rain or irrigation.

Greasy spot is extremely difficult to control with fungicides, although a few instances of good control have been reported.

Pythium Seed Rot and Damping Off: Certain species of Pythium are responsible for seedling disease which accounts for poor stands of grass grown from seed. Pythium may cause a seed rot and prevents germination or it may attack the seedling once it has emerged from within the seedcoat. Generally, the damage is done to the plant shortly after emergence. The seedlings have a water-soaked appearance and will collapse on the soil. In old plants infected rootlets become black from the tip back and the entire plant will die.

Control:

Plant your winter lawn seed at the recommended time. Consult Arizona Garden Guide "Overseeding Bermuda Grasses for a Winter Lawn" for proper time and planting procedures. Fungicides are available for topical application and control of this fungus. Some seed treated with fungicides can be purchased and more will be available in the future.

Fusarium Blight: A Fusarium sp. is very destructive on our winter grasses. Winter grasses such as Annual and Perennial Rye and Seaside Bent are particularly susceptible when daily temperatures fall below 65°F. and grass blades remain wet for long periods of time. Although most often seen in shaded lawn areas it is not uncommon for the disease to develop in full sun if watering is done late in the day.

The mycelium, appearing as white thread-like masses, covers the leaf blades rapidly. Soon large masses of spores areproduced, which give the grass a powdery appearance.

Control:

Restrict watering in shaded areas to avoid excess water accumulation. Avoid applications of high nitrogen fertilizers late in the fall. Keep grass cut so that a thick mat does not develop.

For most turf diseases preventive maintenance is the best disease control. Listed below are some maintenance practices which will help keep disease at a minimum.

Cultural Practices

1. Use recommended varieties. Bermuda grasses cannot be expected to perform well under cool or heavily shaded conditions; likewise, bluegrasses do poorly under hot and dry climatic conditions. Consult your local Cooperative Extension Service office for local recommendations.

2. Fertilize properly. Apply high nitrogen fertilizers carefully. Keep grass growing vigorously, but avoid overstimulation by excess nitrogen. Soft, succulent grass resulting from high nitrogen rates is more susceptible to fungal disease. Use nitrogen fertilizer such as ammonium sulphate and apply in small quantities periodically (3-5 lbs/1000 sq. ft. every 6 weeks) rather than in lump applications once or twice a year. To prevent disease losses in cool season grasses, such as Kentucky bluegrasses, fine-leaf fescues, and bent grasses, do not apply nitrogen fertilizer during the summer (July through September). Fertilize cool season grasses in the late fall or early winter and again in late winter or early spring.

3. Use common sense watering practices. Many lawn disease problems are the result of poor watering practices. A common problem is inadequate placement of sprinklers. Some areas of the turf simply do not get enough water and the resulting moisture stress promotes invasion by a fungus such as Helminthosporium. Place sprinklers so that the turf gets uniform coverage and water penetrates soil to a depth of one foot or more. A rule of thumb is that about one inch of water is required to wet an average loam soil to a depth of one foot. An application of 1 or 2 inches of water per irrigation is desirable. Coffee cans or similar type containers may be used to measure the sprinkler output. Some sprinklers may require six hours to provide one inch of water, while others may apply one inch in 45 minutes. When grasses have developed a deep root system daily watering is not needed. Deep irrigation applied by sprinkler every 5 to 7 days should be sufficient for most lawns during the hottest months. Some lawn areas must be watered to a depth of several feet in order to apply sufficient water for nearby trees. Syringing or a light sprinkling of the lawn in the early morning is an important measure for the prevention of disease caused by sporulating fungi such as Helminthosporium. The primary reason for this early morning water is to remove guttation droplets which accumulate overnight at the tips of the leaves. These droplets serve as an excellent source of nutrients for many of the fungal pathogens attacking grasses. Dilution of these droplets removes a source of nutrition for the fungi; the leaf blades also dry more quickly once the droplets are dispersed. The need for early morning syringing is especially important after an application of a readily soluble nitrogen fertilizer such as ammonium sulphate. Nitrogen fertilizers increase the concentration of organic nutrients available in the guttation fluid. Syringing should not be considered a substitute for irrigation because it does not provide enough water.

4. Use common sense mowing practices. Cutting grass too closely or scalping it during summer months may result in a condition that looks like a disease. In order to prevent this, do the following:

   a. Scalp and power rake (or hand rake) common bermuda and hybrid bermudas in early spring to remove thatch accumulation. Then maintain a mowing height of ½ to one inch for the duration of the growing season.

   b. Cut bluegrass and other cool weather grasses with upright growth habits to a height of 1-3/4 to 2 inches. Do not lower the height of cutting in mid-season; it may result in serious injury. Mow grass before it gets too tall; not more than one-third to one-half of the leaf surface should be removed at any one time. The frequency of mowing will depend on the quantity of fertilizer and water applied, weather conditions, and other factors that influence plant growth but during the active growth period lawns should be mowed at least once a week. Clippings should be removed when growth becomes luxuriant and increased mowing is required. Unrotted accumulations of leaf material provide a suitable place for pathogenic fungi to develop and, in addition, water penetration will be impaired.

   If excessive thatch accumulation occurs, decomposition is hastened by cultivation and light top dressing with fertilizer. Also, bermuda grass, some of the fine-leaved Zoysias and hybrid bermuda grasses accumulate thatch so rapidly that mechanical removal is desirable. Power renovating or raking machines are available on a service or rental basis in most areas.

Chemical Prevention and Control of Turf Diseases

Chemical usage complements other sound cultural practices. Fungicides and nematocides should only be applied for specific reasons. Indiscriminate application of chemicals leads to the elimination of beneficial organisms which ordinarily prevent damage by fungi and nematodes, causing disease.

If a turf disease appears, it is important to take action as quickly as possible. First, determine if in fact you have a disease problem. Contact your county agent or a commercial consultant, such as a nursery, or an agricultural chemical company to make a diagnosis. Secondly, if a disease problem is indicated, learn what fungus or nematode is the culprit and use a chemical effective against that particular organism. An effective chemical is the key to good control since chemicals are often quite specific for the fungi or nematodes they control. Remember to read the label on all chemical containers and follow the instructions exactly. Effective control depends upon proper application.

Some Fungicides Available for Prevention and Control of Turf Diseases

DISEASE	FUNGICIDE
Melting Out (Helminthosporium & Curvularia)	Actidione - Ferrated
	Actidione - RZ
	Actidione - Thiram
	Daconil 2787
	Difolatan (Folacid)
	Dithane M-45 (Fore)
	Dyrene
	Folpet (Phaltan)
	Kromad
	Maneb (Tersan LSR, Dithane M-22)
	Zineb (Dethane Z-78, Parzate)
Brown Patch (Rhizoctonia)	Actidione RZ
	Daconil 2787
	Difolatan (Folacid)
	Dithane M-45
	Dyrene
	Kromad
	Mertect 140F
	Maneb (Tersan LSR, Dithane M-22
	Tersan 1991
	Terraclor
	Zineb (Dithane Z-78, Parzate)
Greasy Spot (Pythium)	Chloroneb (Tersan SP)
	Dexon
	Koban (Truban)
	Terrazole
Fusarium Blight	Cadminate
	Tersan SP
	Daconil 2787
	Dithane M-45
	Dyrene
	Mertect 140F
	Tersan LSR
	Tersan 1991

DISEASE (cont)	FUNGICIDE (cont)
Mushrooms & Fairy Rings	Dyrene
Nematodes	DD Dowfune MC-2 Dowfune W-85 EDB Fumazone 70-E Larvacide Methyl Bromide Nemagon EC-2 Vapam
Damping Off and Seed Rot	Captan Koban Tersan SP

Diseases of Ornamental Landscape Plants

The most common diseases found on ornamentals in Arizona include Phymatotrichum root rot, Verticillium wilt, fire blight, grown gall, powdery mildew, stem gall, and bud rot of palm, and a list of less important diseases:

Aleppo Pine Blight

Cause

Physiological, associated with low soil moisture/hot, drying winds.

Symptoms

1. Bronzing, chlorosis or death of needles on one or more branches or on entire tree, in October-November or March-May.
2. Needles remain on tree for several months.

Control

1. Maintain uniform water supply to tree all year.
2. Water deeply.
3. Maintain moderate levels of nitrogen for tree all year.
4. In new plantings, eliminate caliche deposits; dig hole at least 5' x 5' x 5; provide for drainage of excess water.

Ash Decline

Cause

Unknown. May be related to physiological disorders induced by inadequate soil moisture/hot, drying winds.

Symptoms

1. Marginal burning of leaves.
2. Branch and twig die-back.

Control

(See Aleppo Pine Blight)

Brown Rot Gummosis

Cause

Fungal (Phytophthora parasitica and P. citrophthora)

Symptoms

1. Cracking of bark at or below soil level with associated cambium discoloration.
2. Profuse gumming in advanced stages.
3. Yellow, sparse foliage.

Spread

1. Motile spores in water around diseased tree.
2. Soil from diseased tree.

Control

1. Remove soil to expose lower trunk and upper butress roots to promote drying.
2. Construct dike to keep water from exposed area.
3. Remove diseased tissue and paint with copper fungicide.
4. Use trees with sour orange rootstocks (resistant) for new plantings.

Bud Rot of Palm

Cause

Fungal (Phytophthora palmivora)

Symptoms

Collapse and death of heart fronds in growing point during warm, rainy periods.

Spread

Spores from diseased palms spread by blowing rains.

Note - Species may vary in their susceptibility. Reports indicate that the Washingtonia and Arecastrum species may be more susceptible than the others listed.

CONTROL- The crown and bud portions of the palm can be sprayed or drenched twice a year with a copper fungicide as a preventive. Applications should be made in May or June and again in November or December.

Citrus Nematode

Cause

Nematode (Tylenchulus semipenetrans)

Symptoms

1. Progressive decline.
2. Defoliation of branch tips.

Spread

Water, soil or roots from diseased tree.

Control

Apply a Nemagon or Fumazone drench.

Crown Gall

Cause

Bacterial (Agrobacterium tumefaciens)

Symptoms

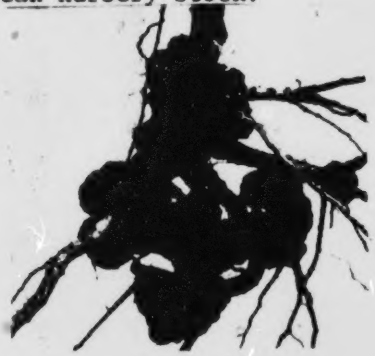
1. Progressive decline.
2. Large spherical galls (up to 6 inches in diameter) on roots and crown (below ground).
3. Severe infection may result in death of plant.

Spread

1. Diseased nursery stock.
2. Soil from diseased plant.

Control

1. No recommended treatment for diseased plants.
2. Plant clean nursery stock.



(Crown Gall on Peach)

Cytospora Canker

Cause

Fungal (Cytospora chryosperma)

Symptoms

1. Peeling of bark.
2. Branch die-back.

Signs

1. Tiny black specks on bark with or without orange exudation.

Spread

Spores are spread by splashing rain or sprinkler water.

Control

1. Prune out diseased limbs in early spring.
2. Disinfect pruning cuts and tools with 50% household bleach. (1 part bleach to 1 part water).
3. Apply tree-sealing compound.
4. Dispose of pruned limbs.
5. Repeat yearly until tree has recovered.

Fig Mosaic

Cause

Virus

Symptoms

1. Yellow spots and/or circles on leaves and/or fruit giving a mosaic pattern.
2. Some dwarfing and distortion of leaves.

Spread

Transmitted by eriophyid mites, cuttings and budwood.

Control

1. Control mite (consult extension entomologist for recommended chemicals).
2. Use healthy budwood.

*Signs of plant diseases are distinguished from symptoms as follows:

1. Sign - visible evidence of the disease organism such as the powdery mildew fungus on rose leaves.
2. Symptom - visible or recognizable changes in plant appearance caused by the disease such as yellowed leaves, twig die-back etc.

Fireblight

Cause

Symptoms

1. Die-back of branch tips. Burned appearance on twigs, branches, flowers and leaves.
2. Water-soaked cankers on twigs and branches.
3. Severe infections result in death of tree.

Spread

Bacterial ooze from twig and branch cankers spread by insects or splashing rain.

Control

1. Remove blighted or diseased branches below infected tissue.
2. Paint cut surfaces with 50% household bleach.
3. Spray bactericidal or copper compounds during flowering period to prevent blossom infections.
4. Plant resistant varieties: Pear (Old Home, Kieffer)

Frost Injury

Symptoms

1. Burned appearance of twigs, leaves or flowers.
2. Cracks or splits in limbs or trunks.
3. Death of frost sensitive species. (This may not be evident in deciduous species until spring.)

Control

1. Avoid fall fertilizer applications after September 1; reduce frequency of irrigations after October 1.
2. Deep water before a severe frost if soil is dry.
3. Cover tender plants.

Heart Rot

Cause

Fungal (Polyporus munzii)

Symptoms

Rotting of heart wood.

Signs

Presence of fungal conks (fruiting bodies) on trunk of tree.

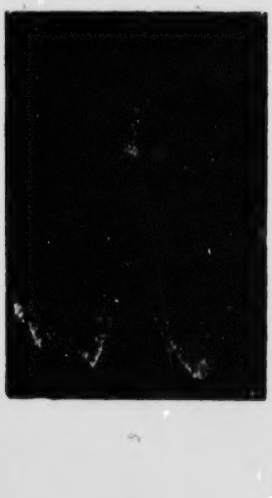
Spread

Airborne spores

Control

1. Remove and destroy conks.
2. Avoid excessive pruning which may provide a point of entry for fungal spores. Protect pruning cuts with tree paint.

Iron Chlorosis



Iron is one of the essential elements for plant growth. Lack of iron causes poor growth or plant death.

Iron chlorosis is common in the alkaline soils of the Southwest. Factors which reduce the availability of iron are excessive phosphate fertilization, over-irrigation, poor drainage, and high soil alkalinity.

Symptoms - Iron chlorosis is characterized by yellowing of leaves, particularly between the veins. (See Photos) Severely affected plants may fail to grow, flower, or fruit. In conifers, the needles turn yellow and frequently drop.

(Iron Chlorosis with normal leaf on left)

Control - There are two methods of control: 1) Apply soil sulfur at four pounds per 100 square feet to reduce soil alkalinity; apply iron chelates as directed; do not overwater; 2) Use iron sulfate (see following table); do not overwater. Iron sulfate: Use one ounce per square foot. One ounce is two level tablespoons.

A. Shrubs - Place iron sulfate in trench or holes tree to six inches deep around drip line. Refill with soil. Water thoroughly.

B. Trees - Follow suggestions given below:

Soil Application -
Approximate Rates for Iron Sulfate

Diameter in ft. (drip line)	No. Level Tablespoons	No. Cups	No. Lbs.
1	2		
2	6	1/3-½	-
3	14	1	½
4	26	1½	3/4
5	40	2½	1¼
6	--	3½	1 3/4

For annual flowers, use one tablespoonful of iron sulfate per linear foot of row placed in a shallow trench (one to two inches deep) about two to three inches from the plants.

Treatment should be made during March or April in Southern Arizona and April and May in Northern Arizona. Watch for symptoms of iron deficiency during August and September.

Iron chelates are more effective and quicker acting than inorganic sources of iron.

Mistletoe

Cause

Parasitic plant (Phoradendron californicum)

Symptoms

Swelling of limb or branch at mistletoe infection site.

Sign

Presence of mistletoe plant.

Spread

Birds

Control

1. Prune out infected branches one or more feet from infected area in direction of trunk
2. Repeat when new infections are noticed.

Phytophthora Root Rot

Cause

Fungal (Phytophthora parasitica and P. citrophthora)

Symptoms

1. Death and decay of roots.
2. Yellow, sparse foliage.

Spread

1. Motile spores in water around diseased tree.
2. Soil from diseased tree.

Control

1. Allow soil to dry between irrigations; wet soil conditions promote growth of this fungus.
2. In new plantings, use varieties with resistant root stocks: a. Sour Orange-resistant; b. Troyer Citrange-moderately tolerant.

Root Knot Nematodes

Cause

Nematode (Meloidogyne sp.)

Symptoms

1. Stunted growth, sparse foliage, premature wilting (small-leaf symptom is associated with severe root infection of mulberry).
2. Root galls (usually less than ¼ to 1/8 inch in diameter) occurring on small roots.
3. Very severe root infection can result in plant death.

Spread

1. Contaminated nursery stock.
2. Soil adjacent to diseased trees.
3. Irrigation water from diseased tree.

Control

Apply a Nemagon or Fumazone drench.

Scaly Bark Psorosis

Cause

Viral

Symptoms

1. Blistered areas on trunk, limbs of trees over 6 years old.
2. Small flecks of gum in wood of main trunk, branches, resulting in large areas of dry, scaly bark.
3. Overall tree decline.

Spread

By grafting or using budwood from diseased trees.

Control

Do not use budwood from diseased trees.

Note: This viral disease usually occurs in older trees.

Slime Flux or Wetwood

Cause

Bacterial (Erwinia nimipressuralis - E. salicis complex)

Symptoms

1. Water soaked areas usually in branch crotches near trunk; at pruning cuts.
2. Dark, foul-smelling liquid oozes from crack in water-soaked area.
3. Associated limb die-back.

Spread

Unknown

Control

1. Bore hole several inches below diseased area.
2. Hammer in drain pipe to prevent sap from running down bark surface.
3. Remove diseased tissue.
4. Paint wound surface with 50% household bleach (1 part bleach to 1 part water).
5. Allow surface to dry; coat with copper compound.
6. Apply tree-sealing compound.

Sooty Canker

Cause

Fungal (Hendersonula toruloidea)

Symptoms

1. Splitting and peeling of bark.
2. Leaves turn brown, remain on tree followed by branch die-back.
3. Severe infection may result in limb die-back.
   Death of tree may result if trunk becomes girdled.

Signs

1. Black masses of fungal spores located under peeled bark.

Spread

Air-borne spores blown to open wounds (pruning cuts or sunburned limbs).

Control

1. Remove infected limbs, branches (delay severe pruning until tree is dormant).
2. Cut out diseased area on main trunk.
3. Treat cut surfaces with 50% household bleach (1 part bleach to 1 part water).
4. Apply copper fungicide or paint with tree-sealing compound.
5. Repeat yearly until infections are gone.
6. Remove severely diseased trees.

Stubborn Disease

Cause

Mycoplasma (Spiroplasma citri)

Symptoms

1. Stunted growth.
2. Multiple small brushy shoots causing flat-top appearance.
3. Small leaves.
4. Gradual flattening out of tree top.
5. Acorn-shaped fruit, often with grainy texture.

Spread

1. Use of budwood from diseased trees.
2. Insect transmitted by the leaf hopper Scaphytopius nitridus.

Control

Avoid using diseased trees for budwood.

Sun Burn

Symptoms

1. Yellow or brown areas on leaves usually on south, southwest side of plant. Eventual loss of leaves may occur.
2. Death of bark on trunk or limbs on south, southwest side of plant. Later, sunburned bark may crack and peel.
3. Death of very sensitive tree species.

Control

1. Check for sun and heat tolerance before planting.
2. Plant only tolerant species against hot, unshaded south or west-facing walls.
3. During hot summer months, sensitive species grown as container plants should be located in part to full shade; protected from strong winds.

Phymatotrichum Root Rot

Often referred to as "Texas Root Rot", attacks a wide range of ornamentals. It attacks only dicotyledonous plants. Root rot is the most important disease in Arizona because it attacks such a wide range of plants and will spread from one plant to another.

Root rot attacks the roots of a plant and when many roots are killed the plant suddenly wilts and dries (usually attached to the tree). The fungus that causes the disease is most destructive during the summer months when soil temperatures are high (usually June-September); however the fungus is also active during the cooler months although no symptoms may show.

Symptoms

Above ground symptoms are sudden collapse of foliage and drying of the foliage. Some species of ornamentals appear to die overnight. The foliage in spring which is yellow or pale green indicates infection late the previous summer. Such trees usually die the following summer. Symptoms show when the plant is stressed during the hot summer.

Identification

Phymatotrichum can be recognized by the presence of "spore mats" of fungus on moist soil following irrigation or during the rainy season.

The first day these mats are cottony white in texture, round or irregular in shape and 3-12 inches across. After 3-4 days they become light tan and powdery. When this occurs under a visibly sick tree, it is a very good indication of the presence of Phymatotrichum root rot.

Positive identification can be made by taking a sample of the tiny strands found on the roots of suspect trees and examining using a microscope. The strands show slender straight side branches with "cross arms". This gives positive identification as this is characteristic of no other fungus.

NOTE: Identification of root rot as well as other disease is usually performed by members of the Agricultural Extension Service, the Extension Plant Pathologist, or your County Agent. When necessary, the examination under the microscope will be done by the research staff of the Plant Pathology department. Contact your County Agricultural Agent whenever possible.

Prevention

Pre-plant fumigation in infected soils utilizing Vapam or VPM is often used. Caution must be taken to prevent damage to living trees and should not be used within five feet of the drip line of living plants. READ THE MANUFACTURER'S DIRECTIONS ON THE LABEL!

Treatment

Once root rot is detected treatment incorporating ammonium sulphate or ammonium phosphate, sulfur and manure is used.

1. Loosen the soil around the tree or shrub out to the drip line of the branches.
2. Cover the area to a depth of 2" with manure. This should be partially decomposed but need not be screened.
3. Scatter ammonium sulphate or phosphate at the rate of 1 lb. to 10 sq. ft. and manure around the tree.
4. Scatter the same amount of sulphur as the ammonium sulphate.
5. Flood irrigate to a depth of 3 feet.
6. If the tree is shedding leaves or drying on the tree, cut back severely by removing about ½ of the top growth.

Very Susceptible species

Umbrella tree
Bottle tree
Cottonwood
Elm (Chinese)

Moderately susceptible species

Fruitless mulberry
Pecan
Pyracantha
Rhus lancia
Euonymous
Jasmine
Privet

Resistant

Eucalyptus
Oleander
Pomegranate

NOTE: Prevention is the best approach to root rot. Treat adjacent trees with the manure, sulphate, sulphur mix whenever root rot breaks out in an ornamental planting.

Verticillium Wilt

Cause

Fungal (Verticillium albo-atrum)

Symptoms

1. Inward rolling of leaves, loss of deep green color (olive only).
2. Drying of foliage and branches or limb die-back progressive throughout tree.
3. Vascular discoloration may be present in affected limbs.

Spread

1. Infected nursery stock.
2. Contaminated soil.

Control

1. Mix sawdust mulch (¼ - ½ lb./sq. ft.) into ground beneath tree, plus a nitrogen fertilization (¼ - ½ lb. of actual nitrogen per 100 sq. ft.)
2. Plant resistant type (Oblonga).

Zinc Deficiency (Rosette)

Cause

Zinc deficiency

Symptoms

1. Small yellow-green leaves with rough texture.
2. Brown dead spots occurring between leaf veins.
3. Clumping (rosetting) of small twigs, branches.
4. New foliage in small tufts.

Control

Apply zinc sulfate in 3-inch deep trench or holes near drip line (1 pound/inch of trunk diameter). Spray application during early spring is also effective (½ pound zinc sulfate and 1/8 pound of hydrated lime/ 6 gallons of water).

Nematodes

Nematodes are minute roundworms that are very common and widespread in soil, water and other habitats.

Of the more than 10,000 described species of nematodes, more than 200 species are known to be plant parasites. Most plant parasitic nematodes feed in or on roots and other below ground plant structures, although some are known to feed in buds, stems and leaves.

All plant parasitic species have a stylet or spear which enables the nematode to feed on roots or other plant parts.

Symptoms

Symptoms of nematode injury to plants vary with type of plant, plant age, cultural conditions of plant growth, kind of nematode and degree of infestation. Since nematodes most commonly damage root systems, the above-ground symptoms are essentially the same as those caused by an inadequately functioning root system as reflected in lack of vigor, wilting, premature leaf fall, yellow foliage, stunting and twig and branch die-back.

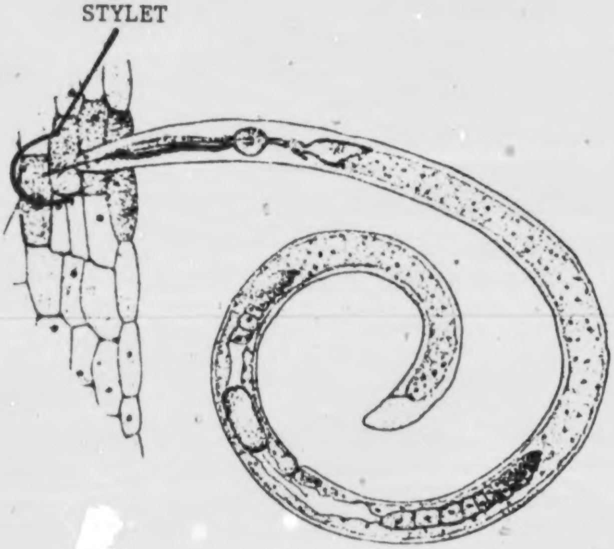
Infected plant roots may be galled, decayed, rough, stubby, swollen or blackened and discolored. Nematode damage usually is blamed on lack of fertilizer, water or poor soil condition.

One of the most common nematodes in Arizona is the root-knot nematode, so called because of the characteristic knots or galls that are produced on roots and other below-ground plant parts. These galls are easily seen without magnification.

In heavily infested soils, the root systems of infected plants can resemble a string of beads.

Control

A. Cultural Practices
   1. Rotation - If nematodes are known to have caused damage to a previous crop, a new planting site should be chosen if land is available. A three to four year rotation program should be practiced, if possible.
   2. Fallow and Dry Tillage - Dry summer fallow accompanied by frequent cultivation may effectively control the root knot nematode if weeds are removed.
   3. Sanitation - As soon as annual plants are harvested or pulled after bloom is finished all roots should be removed from the soil and disposed. Do not use roots for compost. Buy clean transplants. No matter how careful you are in carrying out all other precautions, your efforts are largely wasted if nematodes are brought in on infested plants or tools.



Drawing of a nematode feeding on a grass root cell.
(Nematodes range in size from 1/75 to 1/10 inch in length.)

ROOT GALLS CAUSED BY NEMATODES

A NEMATODE
MAGNIFIED
100 TIMES

B. Chemical Methods

Treatment of the soil with chemicals (nematicides) is the best method of controlling nematodes. Several types of chemicals and methods of application are available. Some chemicals may be applied prior to planting (preplant). They may be injected into the soil, drenched, sprayed or sprinkled onto the soil surface, applied into furrows along the row to be planted, or applied with irrigation water.

These methods, when properly used, are inexpensive, safe and effective. There are several steps to take prior to using a nematicide. They are summarized as follows:

1. Irrigation - The soil should be irrigated and cultivated to a depth of 12 inches or more several weeks prior to treatment. All clods should be broken up and the soil loosened thoroughly. Extremely wet or dry soils should not be treated.
2. Soil Temperature - At the time of treatment the soil should be in good seedbed condition with a temperature between 55 and 80 degrees Fahrenheit at the five inch level. Application of nematicide should follow an irrigation by seven to ten days.

The use of several nematicides is described in Table 1. Since DBCP (Fumazone and Nemagon) is the only nematicide that may be used around living plants, a list of tolerant, moderately tolerant and plants susceptible to DBCP is shown in Table 2. Application methods for DBCP are outlined in Table 1.

CONTROL CHEMICALS

A list of chemicals useful in controlling plant diseases. In many cases the fungicides are found as mixtures in multipurpose sprays and dusts. FOLLOW LABEL DIRECTIONS.

CHEMICAL	TRADE NAMES	USES AND REMARKS
Captan (wettable powders and dusts)	Captan (orthocide, soil and Bulb Dust). Many others.	Leaf and blossom spots of shrubs, fruits and trees; fruit rots; seed treatment of flowers, grasses, and vegetables; corn, bulb and tuber decays; damping-off and seedling blights; in many multipurpose sprays and dusts for fruits and flowers.
Maneb, Maneb and zinc ion (wettable powders and dusts)	Manzate D, Maneb, Fore or Dithane M-15, Manzate 200, Dithane M-22, Ortho Fungicide, Sears Lawn Fungicide, etc.	Leaf and blossom spots of flowers, shrubs, vegetables and trees; fruit rots; downy mildews; rusts; certain lawn diseases. In many multipurpose sprays and dusts for vegetables, tomatoes and roses.
Zineb (wettable powders and dusts)	Dithane Z-78, Zineb, Ortho Zineb, parzate, etc.	Leaf and blossom spots of flowers, shrubs, trees and vegetables; fruit rots and scabs; downy mildews; rusts; certain grass diseases, damping-off and seedling blights. In many multipurpose sprays and dusts for vegetables and ornamentals.
Thiram (wettable powders and dusts)	Tersan Thiram Fungicide, Arasan, etc.	Seed and bulb treatment for flowers, vegetables and grasses; damping-off and seedling blights; leaf and blossom spots, blotches or blights of flowers, vegetables, fruits, shrubs, and trees; rusts; broad-spectrum lawn grass fungicide.
Fixed or neutral coppers (wettable powders, dusts and liquids)	Tri-Basic Copper Sulfate, Coposil, Niagara C-O-C-S, Basic Copper Fungicide, etc.	Bacterial leaf spots and blights of all plants; fireblight.
Dinocap (wettable powders, dust and liquid)	Karathane-WD, Mildex, Karathane Liquid, and Karathane Dust	Powdery mildews of all plants; in many new multipurpose sprays and dusts.
Household Bleach	Clorox, Purex, Saniclor, etc.	Disinfectant for tools when pruning to control fireblight cankers, crown gall, tree decays.
Sulfur products (wettable powders, dusts, pastes, liquids)	Many brands	Powdery mildews of all plants; brown rot and scab of stone fruits; certain rusts.
PCNB (wettable powders, dusts, emulsifiable concentrate)	Terraclor, etc.	Certain root, stem and crown rots of vegetables, turf grasses and ornamentals; damping-off and seedling blights, often mixed with captan, maneb, zineb, etc.
Ferbam and Ziram (wettable powders, dusts)	Many	Related to zineb, maneb and thiram and used for many of the same purposes.
Difolatan, Folpet (Phaltan)	Many	Related to captan and used for many of the same purposes.
Cycloheximide (wettable powders; acti-spray is in tablet form)	Acti-dione, Acti-spray, Acti-dione-Thiram, Acti-dione PM	Powdery mildew; certain rusts; several lawn diseases.
Cadmium, Thiram-and-Mercury-containing turf fungicides (wettable powders, liquids)	Caddy, Ortho lawn and turf fungicide	Control specific turf grass diseases such as **Sclerotinia** dollar spot, brown patch, snow mold, etc.
Dexon (wettable powder, granules)	Dexon	Seed, turf and soil fungicide for controlling Pythium diseases and those caused by other water molds. Also sold in combination with Dyrene, PCNB, and captan.
Streptomycin (also with Terramycin or copper sulfate), (wettable powders)	Agrimycin 17, Ortho streptomycin spray, agristrip	Fireblight; bacterial spots and blights of vegetables, fruits and flowers.
Metiram (wettable powder, dusts)	Polyram	Rust; downy mildew; leaf spots, similar to maneb in range of effectiveness.

Weeds

A weed is simply "a plant out of place". Weeds are a problem because:

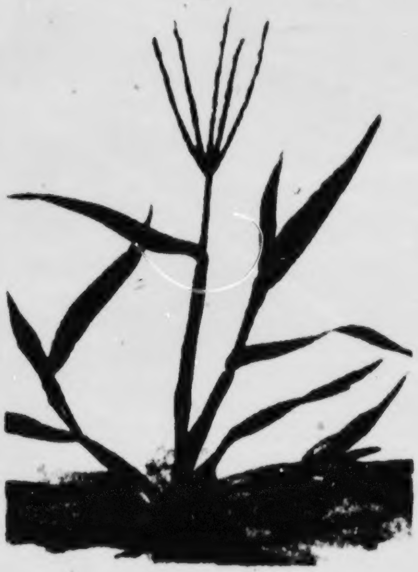
- they reduce crop yields,
- they increase costs of production,
- they reduce quality of crop and livestock products,
- some cause skin irritation and hay fever. Some are poisonous to man, his livestock, and wildlife, and
- they spoil the beauty of turf and landscape plants.

Recognizing Common Features of Weeds

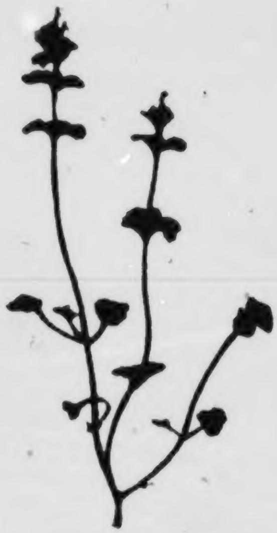
Before you can control weeds, you need to know something about how they grow. One important feature is the length of their life cycle.

Annuals

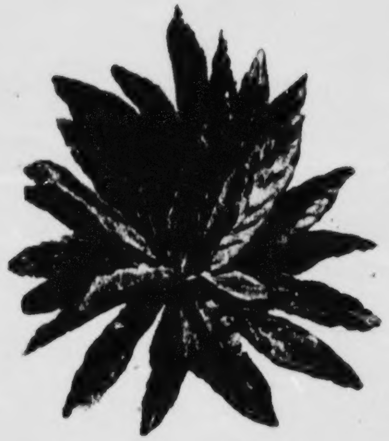
Plants with a one-year life cycle are *annuals*. They grow from seed, mature, and produce seed for the next generation in one year or less. They may be grasslike (crabgrass and foxtail) or broadleaved (pigweed and cocklebur).



Summer annuals are plants that result from seeds which sprout in the spring. They grow, mature, produce seed, and die before winter. Examples: crabgrass, foxtail, cocklebur, pigweed, and lambsquarters.

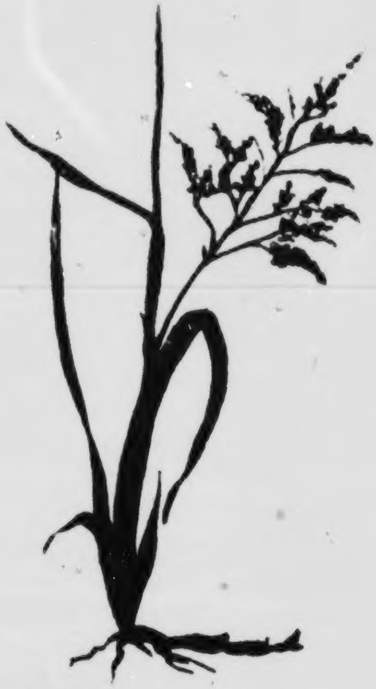


Winter annuals are plants that grow from seeds which sprout in the fall. They grow, mature, produce seed, and die before summer. Examples: cheat, henbit, and annual bluegrass.



Biennials

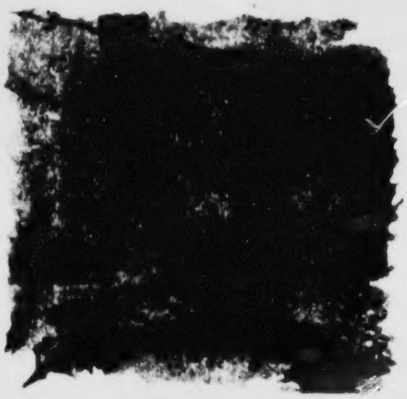
Plants with a two-year life cycle are *biennials*. They grow from seed and develop a heavy root and compact cluster of leaves the first year. In the second year they mature, produce seed, and die. Examples: mullein, burdock, and bull thistle.



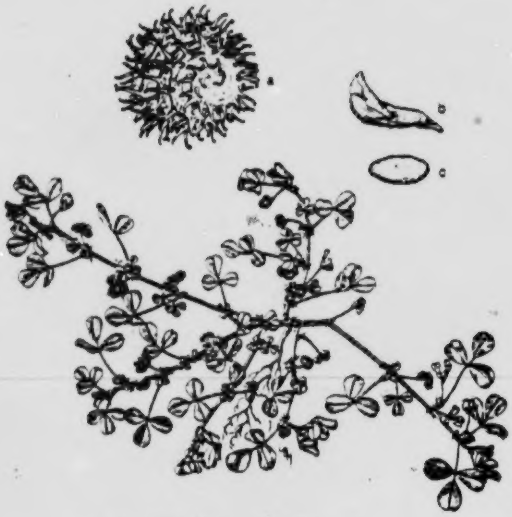
Perennials

Plants which live more than two years and may live indefinitely are *perennials*. During the winter, many lose their foliage and the stems of others may die back to the ground. Some grow from seed. Others produce tubers, bulbs, rhizomes (below-ground rootlike stems), or stolons (above-ground stems that produce roots). Examples: Johnson grass, field bindweed, dandelion, and plantain.

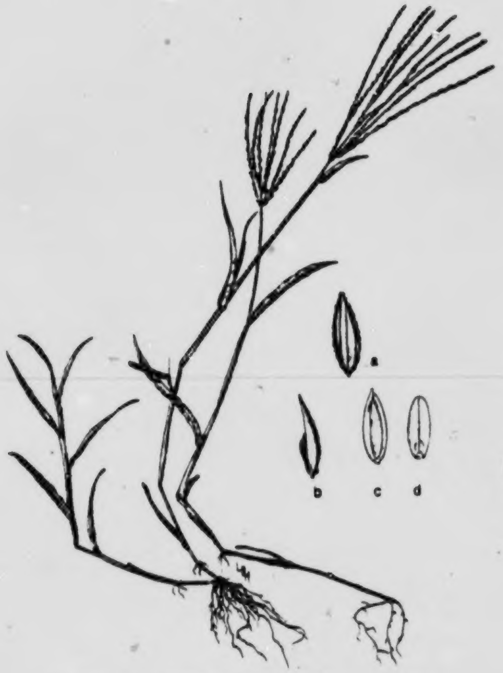
Creeping perennials produce seeds but also produce rhizomes and stolons. Examples: Bermuda grass, Johnson grass, and field bindweed.



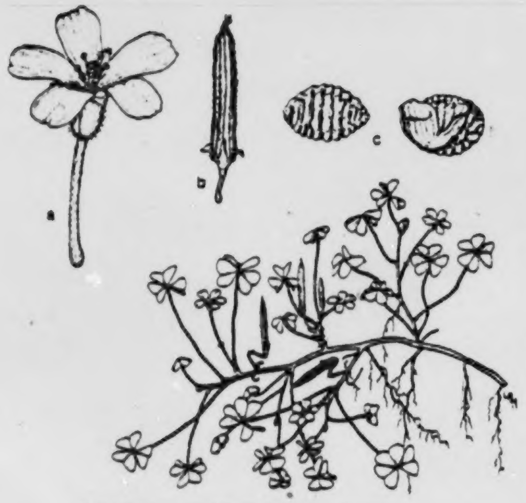
Simple perennials normally reproduce by seeds. But root pieces may produce new plants following mechanical injury during cultivation. Examples: dandelions, plantain, trees, and shrubs.



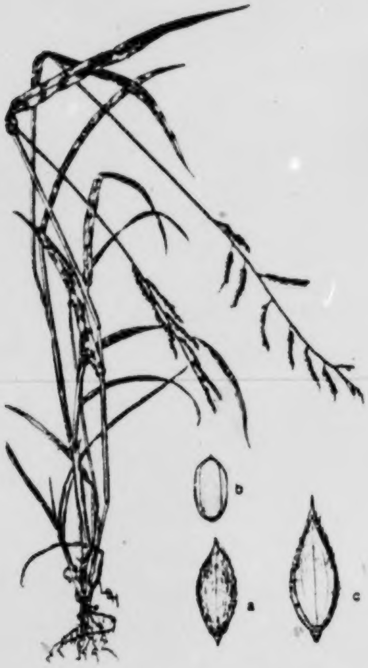
Bur Clover - A bright green nearly hairless annual or winter annual reproduced only by seeds. It has a low growth, hugging the ground with ascending tips. Flowers resemble that of a pea and are yellow and are formed 3-5 to a cluster. Seed pods are straw colored when mature and contain several kidney shaped seeds. Seeds are yellowish or tan colored 1/8 inch long and slightly sticky. Similar in appearance to alfalfa with alfalfa being an erect perennial.



Crabgrass (large and smooth) - A summer annual which reproduces from seed and by stems spreading at the base and rooting at the lower joints. Leaves are flat and 1/4-1/3 inch wide. Flower head is similar to common Bermudagrass. A very persistant summer weed forming unsightly rosettes of coarse leaves. Flowers June to October.



Creeping woodsorrel (Oxalis corniculata) - A spreading prostrate perrenial with weak creeping stems 3-8inches long. Reproduces from seed, by stem rooting at nodes and sometimes by underground rhizomes. The leaves close and droop at night. The flowers are yellow and bloom from February to November.



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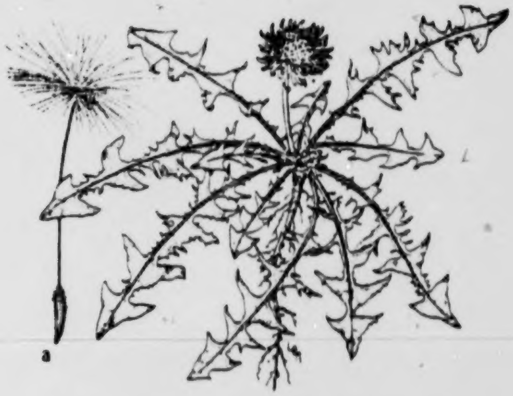

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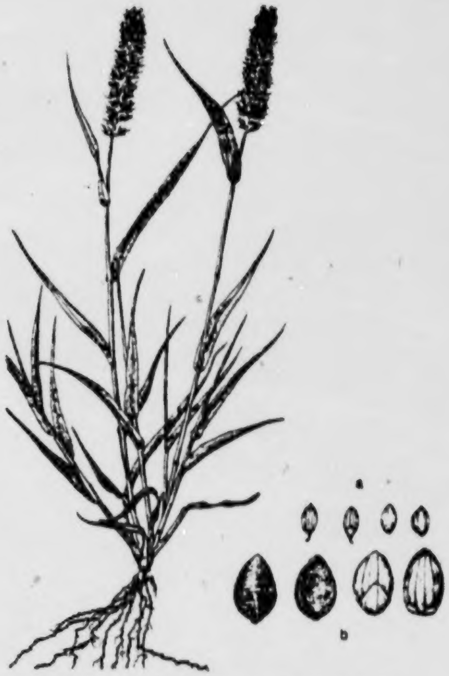
Dandelion - A perennial with a tap root, underground stem, lobed leaves forming a basal rosette. The flower stalk is hollow and bears many seeds which are carried by the wind. The flowers are bright yellow and the seed heads are white and fluffy.

Cupgrass - A spreading annual 1-3 feet high which reproduces by seed and stems rooting at the nodes. It closely resembles crabgrass but does not have hairy leaves. It is very troublesome in summer lawns. Flowers from June to October.

Green Foxtail - A spreading annual forming clumps ½-3 feet high reproduces by seed only. The leaf blades are flattened and usually less than 6 inches long and 1/4-3/8 inches wide. A nuisance in cultivated fields, ditches, and lawns. Flowers June to November.



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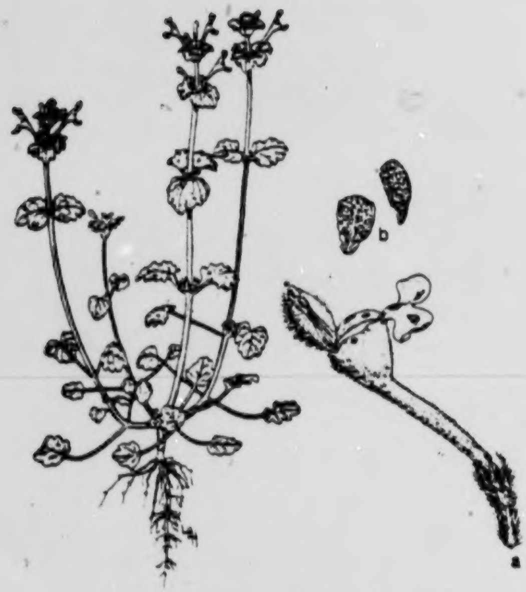

Fig. 118. Henbit (Lamium amplexicaule): Flowering plant a. Enlarged flower. b. Two views of seedlike nutlets

Henbit - An annual, winter annual, biennial, rarely a short lived perennial that reproduces by seed. The plant resembles ground ivy, but the leaves occur opposite along the stem. Stems are 4-16 inches long branching from the base, are erect at first, but soon spreading and rooting at some joints. It has pink or purple flowers, 1/3-3/4 inch long and forms circle of 6-10 flowers around the stem. It is a common pest in new lawns, flower beds and gardens. Blooms February to November.

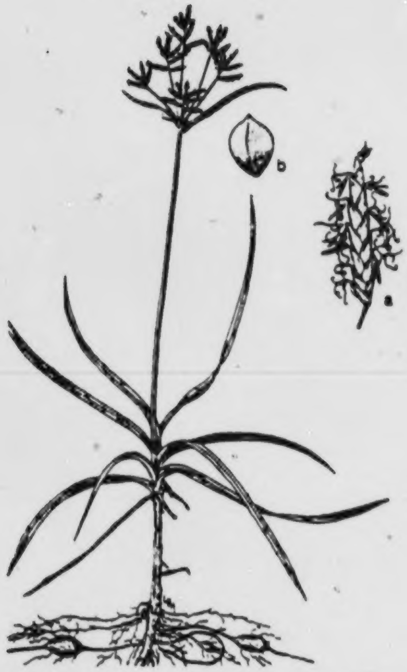

Fig. 22. Purple nutsedge (Cyperus rotundus). Flowering plant showing some of the underground stems with nutlets or tubers at the tips. a. Spikelet in flower. b. Achene.

Nutsedge - A tough perennial 1-3 inches high reproducing by seeds and many deep very slender rhizomes which form weak runners above the ground and small tubers or nutlets at the tips of the underground stems. Nutlets are edible and taste similar to almonds. Flower heads are umbrella like with smaller stems radiating like spokes in a wheel. Leaves are 2-10 inches long and are much longer than the flower stems. Flowers May to frost.

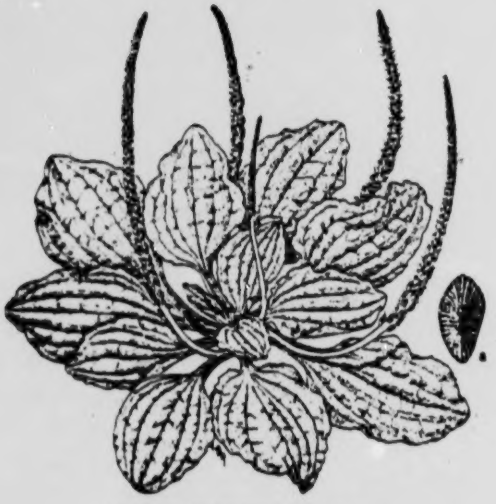

Fig. 128. Broadleaf plantain (Plantago major). Leafy plant with elongated flowering and fruiting spikes. a. Seed.

Plantains - A perennial that reproduces by seed. The leaves form a rosette with flower stalks protruding from the center of the plant. Flower spikes are 3-12 inches long and 1/4-1/3 inch thick. Seeds are similar to Buckhorn but are spread out on the length of the stalk. It is very unsightly in lawns and is particularly objectionable because of this. Flowers March to October.

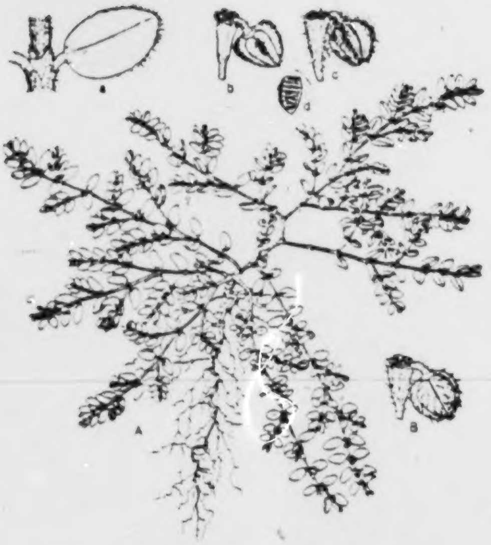

Fig. 98. Groundfig spurge (Euphorbia prostrata). A Prostrate plant. a Leaf showing pair of very small stipules at stalk base, these often lacking completely. b Seedpod with hairs lying close to the surface. c Seedpod with hairs stiffly spreading; in both forms, hairs are on the ridges only. d Seed with sharp cross wrinkles. B Euphorbia supina capsule.

Prostrate Spurge - A low growing annual that generally appears in mid-season. The small leaves are opposite and generally have a red blotch in the center. When broken, a milky sap oozes out. Flowers June to November. It may be a persistent pest in flower beds and summer lawns in Southern Arizona.

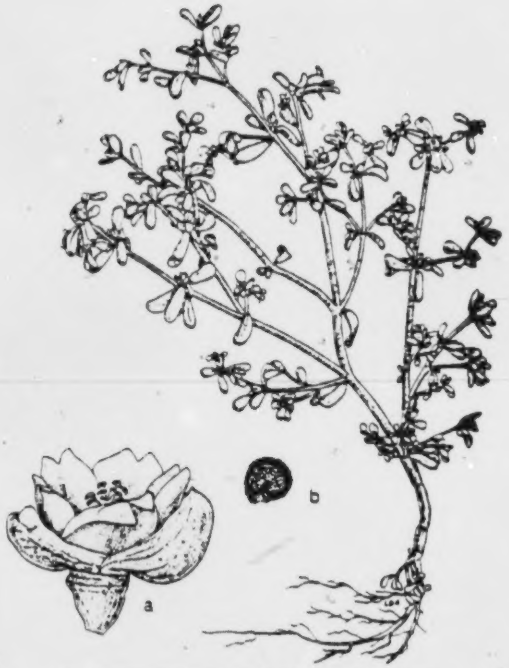

Fig. 62. Common purslane (Portulaca oleracea). Flowering plant. a Flower. b Seed. 133

Purslane - A fleshy leaved annual weed with smooth reddish stems. Quickly invades newer plantings and is often difficult to control. Stems ½-2 feet long and often forming a mat with the tips turned upward. Flowers are yellow and open in the morning. It is a pest of lawns, lettuce, carrots, sugar beets and meadows. Blooms April to June and August to November.

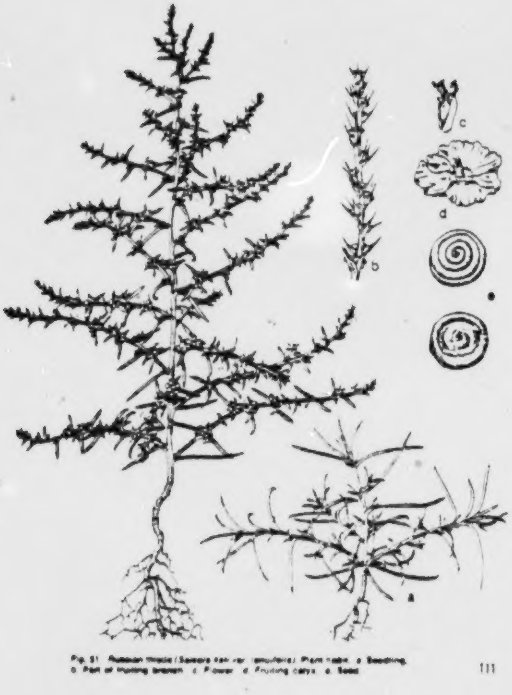

Fig. 51. Russian thistle (Salsola kali var. tenuifolia). Plant habit. a Seedling. b Part of fruiting branch. c Flower. d Fruiting calyx. e Seed. 111

Russian Thistle - A bushy globular annual, ½-6 feet high spiny stems are reddish and are ridgid. At maturity the plant breaks off at ground level and becomes a "tumble weed". The young seedlings are soft and tender without spines. The flowers are without petals but 5 dry flower parts enlarge and form veined wings. It is not often a pest of turf but can be unsightly in border and irrigation areas. Contributes to spread of viruses. Flowers May to November.

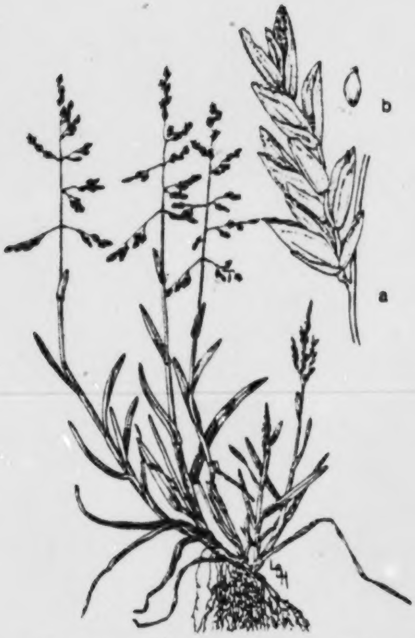

Fig. 27. Annual bluegrass (Poa annua). Flowering plant. a, Spikelet. b, Grain.

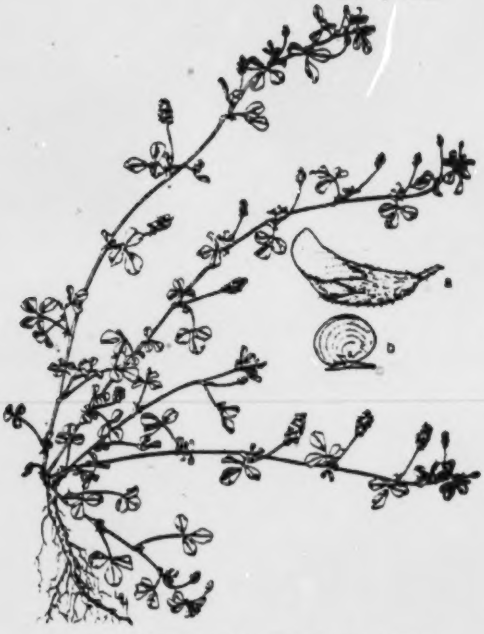

Fig. 84. Black medic (Medicago lupulina). Semi-prostrate plant with flowers and pods on stalked, short spikes, the leaves with three leaflets. a, Pealike flower. b, Pod.

Annual Bluegrass - Low spreading annual which reproduces only by seed. Stems are 4-12 inches long and bright green. Leaves are about 3 inches long. A turf pest which when growing is very luxuriant but dies out with summer heat leaving ugly brown patches. Flowers March to September.

Black Medic or Yellow Trefoil - Is an annual, biennial or perennial that closely resembles white clover. It is distinguished by its yellow flowers and arrangement of its leaflets on the stem. The middle leaflet is borne on a short petiole while the other leaflets are close to the stem. Reproduces by seed only which resembles alfalfa seed. Flowers April to September.

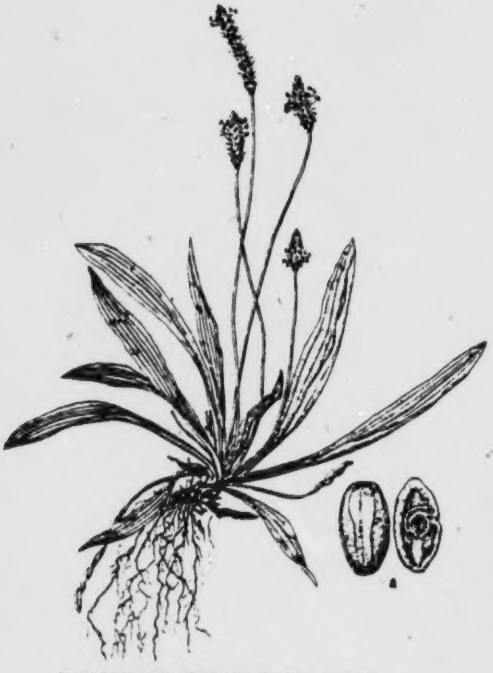

Fig. 129. Buckhorn plantain (Plantago lanceolata). Leafy plant with short flowering and fruiting spikes at tip of the long flower stalks. a, Two views of seed.

Buckhorn - A perennial with lance-like-leaves and bullet-like seeds on long slender stems. Grows up to 1½ feet high. It has a thick fibrous root system. Reproduces mostly by seed but sometimes by new shoots from the roots. The flower stems are longer than the leaves. Flowers April to October.

LAWS AND REGULATIONS

There are several federal agencies which promulgate regulations affecting the pesticide applicator. Each of the agencies and their functions are discussed in the following section.

FOOD AND DRUG ADMINISTRATION

The Food and Drug Administration (F.D.A.) enforces the Federal Food, Drug, and Cosmetic Act, Caustic Poisons Act, Hazardous Substances Labeling Act, Tea Importation Act, and Filled Milk Act. Its activities are directed mainly toward promoting purity, standard potency, truthful and informative labeling of consumer products covered by these laws. The F.D.A. operates under the direction of the Commissioner of Food and Drugs, who is responsible to the Secretary of Health, Education and Welfare.

Safe amounts of pesticides in foods have been regulated through sections 408 and 409 of the Federal Food, Drug, and Cosmetic Act. It has been recognized for some time that contamination of foods might result from use of insecticides in food handling establishments such as canneries, restaurants, and warehouses.

UNITED STATES DEPARTMENT OF AGRICULTURE

The United States Department of Agriculture (U.S.D.A.) is administered by the Secretary of Agriculture and is directed by law to acquire and diffuse information on a broad range of agricultural subjects. The Department performs functions relating to research, education, conservation, marketing, regulatory work, agricultural adjustment, surplus disposal and rural development. It conducts research in agricultural chemistry, the industrial uses of farm products, entomology, soils, agricultural engineering, agricultural economics, marketing, crop and livestock production, production and manufacture of dairy products, human nutrition, home economics, forestry and conservation. It makes research results available for practical farm application through experiment station work in cooperation with the States. The Department provides crop reports, commodity standards, federal meat and poultry inspection service, and other inspection, grading and marketing services. It works toward the eradication and control of plant and animal diseases and pests.

Occupational Safety and Health Act

The Williams-Steiger Occupational Safety and Health Act (OSHA) of 1970 provides for job safety and health protection for all workers. The key provisions of the Act requires that each employer must furnish to each of his employees a place of employment which is free from recognized hazards that are likely to cause death or serious physical harm. O.S.H.A. sets certain standards dealing with toxic materials. It provides for protective equipment to guard against undesirable exposures to liquids, dusts, mists, vapors or gases. It provides for proper storage of pesticides, decontamination, clean up of pesticide spills and safe transportation of pesticides on service vehicles.

DEPARTMENT OF TRANSPORTATION

The Department of Transportation (D.O.T.) regulates the shipment of pesticides across state lines. Each hazardous material being transported must meet D.O.T. standards. These standards regulate warning signs, packaging and classes of poisons that may or may not be transported in the same vehicle. Whenever there is a spill of hazardous materials during shipment, it must be reported to D.O.T.

ENVIRONMENTAL PROTECTION AGENCY

The most significant to the pesticide applicator of all the government agencies is the Environmental Protection Agency (E.P.A.). In 1972 Congress passed a law called the Federal Environmental Pesticide Control Act (FEPCA).

The new Act completely revised the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) which has been the basic authority for Federal pesticide regulation since 1947.

The law prior to the new legislation prohibited interstate commerce of unregistered pesticides, and permitted registration only when if used as directed or in accordance with commonly recognized practice the pesticide would not be injurious to man, vertebrate animals, or desirable vegetation. It did not prohibit the misuse of any registered pesticide, nor did it regulate pesticides that moved only in intrastate commerce.

The new Act regulates the use of pesticides to protect man and the environment and extends Federal pesticide regulation to all pesticides including those distributed or used within a single State.

Major provisions of the new Act will -

- prohibit the use of any pesticide inconsistent with its labeling. No pesticide may be registered or sold unless its labeling is such as to prevent any injury to man or any unreasonable adverse effects on environmental values, taking into account the public interest, including benefits from its use.
- require pesticides to be classified for general use or restricted use. Restricted use pesticides may be used only by or under the supervision of certified applicators or subject to such other restrictions as the Administrator of EPA may determine.
- strengthen enforcement by requiring the registration of all pesticide producing establishments, and regular submission by them of production and sales-volume information; authorizing entry of establishments and other places where pesticides are held for sale or distribution for inspection and obtaining samples; authorizing stop sale, use, or removal orders and seizure against hazardous pesticides if necessary; providing civil and increased criminal penalties; authorizing cooperation with States; and improving procedures governing registration and cancellation actions by allowing scientific review and public hearings to be held concurrently.
- give applicants for registration propriety rights in their test data but establish a mandatory licensing system whereby such data could be used by a second applicant upon the payment of reasonable compensation.

- authorize the Administrator to establish pesticide packaging standards, regulate pesticide and container disposal; issue experimental use permits, conduct research on pesticides and alternatives and monitor pesticide use and presence in the environment.
- provide for certification of pesticide applicators by the States under a program approved by the Administrator; for cooperative enforcement with States; grants-in-aid and other assistance to States. States are also authorized to issue conditional registrations for pesticides intended for specific local use, and could impose greater regulation on a pesticide than that of the Federal government, except as to packaging and labeling.
- establish a series of effective dates for various provisions of the Act and continue the existing law in effect until the new provisions become effective. Every provision of the new Act must be effective within four years.

SECTION BY SECTION SYNOPSIS OF THE MAJOR PROVISIONS OF THE CONFERENCE PESTICIDE BILL

Section 1 of the bill states its purpose and title.

Section 2 of the bill sets forth the amendments to the Federal Insecticide, Fungicide, and Rodenticide Act, as amended:

Amendments to FIFRA

Section 1. Short Title and Table of Contents

Section 2. Definitions

Section 3. Registration of Pesticides

1. With certain exceptions, any pesticide in U.S. trade must be registered with the Administrator.
2. In order to obtain registration, a pesticide producer must submit an application identifying himself and the pesticide, showing the labeling, and stating claims to be made, directions for use, the pesticide formula, requested classification, and test data and results which support the claims made.

   The Administrator may not consider the test data supporting one application in support of another application without the originator's permission or unless the second applicant has first offered to pay reasonable compensation for the test data. If the parties cannot agree on the amount and method of payment, the Administrator makes the determination. If the owner of the test data does not agree with the determination, he may appeal to a Federal district court. The court may not determine that the amount of payment should be less than that determined by the Administrator.
3. All information except trade secrets and privileged information in support of registration must be made available to the public within 30 days of the registration.
4. A pesticide which meets the requirements of the Act shall be registered, and non-essentiality cannot be a criterion for denial of registration.

5. If registration is denied, notice of the denial and reasons for denial must be published in the Federal Register. The applicant then has recourse to administrative and judicial appeals.

6. Registered pesticides will be classified for either general use or restricted use. A pesticide would be restricted because of its potential for harm to either human health or the environment.

   The Administrator may require that the packaging and labeling of a pesticide for its restricted uses be clearly distinguishable from its general uses.

   A restricted use pesticide which is a hazard to human health is subject to the restriction that it be applied by a certified pesticide applicator, who is certified by the State according to standards set by the Administrator and may be either a commercial or private certified applicator.

   A pesticide classified for restricted use because it could harm both health and the environment can be made subject to other restrictions by regulation, which are reviewable in a court of appeals.

   The Administrator may change a pesticide classification but the action is subject to administrative and judicial review.

Section 4. Use of Restricted Use Pesticides; Certified Applicators

1. The Administrator sets minimum standards for the certification of applicators, which are to be separate for private and commercial applicators.

2. Certification will be accomplished by State programs whose plans are approved by the Administrator. The Administrator may withdraw approval of a State plan if the program is not maintained in accordance with it.

Section 5. Experimental Use Permits

1. The Administrator may issue permits and set the terms for the experimental use of a pesticide in order to gather data for registration, and may establish a temporary pesticide residue tolerance level for that purpose.

2. The Administrator may authorize a State to issue experimental use permits under an approved plan.

Section 6. Administrative Review; Suspension

1. Registrations are automatically cancelled after 5 years unless a request is made that they be continued.

2. If the Administrator has reason to believe a registered pesticide does not comply with the Act or that it, when "used in accordance with widespread and commonly recognized practice, generally causes unreasonable adverse effects on the environment", he may move to cancel the registration or change the classification of the pesticide. The registrant is notified and may correct the deficiency or request a public hearing. The Administrator may also decide to hold a hearing on a registration to determine whether or not cancellation or change in classification should ensue.

3. At any time during a hearing a question of relevant scientific fact may be referred by the Hearing Examiner to a Committee of the National Academy of Sciences for a report. The Hearing Examiner may also compel testimony or production of documents by subpoena. Within 90 days from the close of a hearing the Administrator must issue an order regarding the registration in question.

4. If the Administrator finds such action necessary to prevent an imminent hazard to health or the environment during the pendency of cancellation or change in classification proceedings, he may suspend the registration after 5 days notice to the registrant, who may within that period request an expedited hearing on the imminent hazard finding. The suspension order would not take effect until any requested hearing had been completed.

   The Administrator may issue an emergency suspension order, taking effect immediately, when necessary; and any subsequent hearing would be expedited.

5. Final orders of the Administrator under this section are subject to judicial review under section 16. However, orders issued prior to hearing would be reviewed in an appropriate district court.

Section 7. Registration of Establishments

1. Pesticide producing establishments are required to be registered with the Administrator.

2. Producers are required to submit upon initial registration and annually information on the amount of pesticides produced, distributed, and sold.

Section 8. Books and Records

1. The Administrator may require pesticide and device producers to maintain records respecting their operations which are necessary for enforcement of the Act.

2. Records on the location and movement of pesticides or devices are to be accessible to the Administrator's agent upon request for inspection and copying.

3. Financial, sales, pricing, personnel, and research data are excluded from the above requirements.

Section 9. Inspection of Establishments

1. The Administrator's agent may enter any establishment or other place where pesticides or devices are held for distribution and sale, inspect pesticides or devices, and take samples. The agent must state a sufficient reason for his action.

2. A warrant to enter a place and inspect and reproduce records may be obtained when the Administrator's agent shows there is reason to believe the Act has been violated.

3. If a violation of the Act appears to have occurred, the Administrator shall notify the suspected violator, and shall certify the facts to the Attorney General for the institution of criminal or civil proceedings. However, for minor violations the Administrator may issue a warning instead.

Section 10. Protection of Trade Secrecy and Other Information

1. In submitting required data, a registration applicant may mark the portion he considers trade secrets, or commercial or financial information, and submit it separately.
2. The Administrator may not make information public if it comprises trade secrets, or commercial or financial information. However, pesticide formulas may be revealed in certain instances in order to carry out the purposes of the Act.
3. Disputes between the Administrator and an applicant or registrant concerning releasable information would be resolved in a district court by declaratory judgment.

Section 11. Standards Applicable to Pesticide Applicators

1. No regulations under the Act may require a private applicator to maintain records or file reports.
2. Private and commercial applicator certification standards set by the Administrator must be separate.

Section 12. Unlawful Acts

A number of unlawful acts are contained in the section which relate to the requirements of the other sections of the bill pertaining to registration of pesticides and producing establishments, record-keeping and reporting, pesticide use, and others. Additional unlawful acts include not giving a pesticide's classification when advertising and failure to fully inform persons involved in pesticide testing.

Section 13. Stop Sale, Use, Removal, and Seizure

1. When it appears a pesticide is in violation of the Act or its registration has been suspended or cancelled by final order, the Administrator may issue a "stop sale, use, or removal" order to any person.
2. Pesticides in violation of the Act may be seized, as may misbranded devices and pesticides which have an unreasonable adverse effect on the environment even when used in accordance with requirements and as directed on the labeling.

Section 14. Penalties

1. Any registrant, commercial applicator, wholesaler, dealer, retailer, or other distributor is liable to a $5,000 civil penalty for an Act violation. Private applicators and other persons are liable only to a $1,000 civil penalty on their second and subsequent offenses. Opportunity for hearing is required prior to assessment of a civil penalty.
2. Any registrant, commercial applicator, wholesaler, dealer, retailer, or other distributor is liable to a penalty of $25,000 or 1 year in prison or both upon conviction for a misdemeanor. Private applicators and other persons are liable to $1,000 or 30 days in prison or both. Persons who reveal formula information are liable to $10,000 or 3 years in prison or both.

Section 15. Indemnities

1. Persons owning a pesticide whose registration is suspended and later cancelled are eligible for payment by the Administrator of an indemnity for the pesticide owned. Manufacturers who had knowledge prior to the issuance of a suspension notice that their products did not meet registration requirements and who continued to produce the pesticide without notifying the Administrator of the deficiency would not be eligible.
2. In lieu of indemnification the Administrator may authorize under certain limited conditions the use or other disposal of a pesticide.

Section 16. Administrative Procedure; Judicial Review

1. Except as otherwise provided, EPA refusals to cancel or suspend registration or change classifications which do not follow a public hearing are reviewable in district courts, as are other final non-discretionary Agency actions.
2. Review of an order of the Administrator will occur in a court of appeals upon the request of any person who will be adversely affected by the order and who took part in the public hearing leading to the order. The court shall review all evidence of record, and commencement of proceedings does not operate as a stay of an order unless specifically ordered by the court.
3. District courts have jurisdiction to specifically enforce and to prevent and restrain violations of the Act.

Section 17. Imports and Exports

1. Producers of exported pesticides or devices are subject to the requirements of Section 8, Books and Records, but are otherwise required only to prepare the product as specified by the foreign purchases in order to comply with the Act.
2. The Administrator is required to notify foreign governments through the State Department whenever the registration, or the cancellation or suspension of the registration of a pesticide becomes effective or ceases to be effective.
3. The Administrator is authorized to examine imported pesticides or devices and have those in violation of the Act refused entry, seized, and destroyed.

Section 18. Exemption of Federal Agencies

The Administrator may exempt any Federal or State agency from the Act if he determines that emergency conditions exist which require such exemption.

Section 19. Disposal and Transportation

The Administrator shall establish procedures and regulations for storage or disposal of pesticides and containers. He is required to accept at convenient locations for disposal a pesticide whose registration is suspended, then cancelled.

Section 20. Research and Monitoring

Authority for pesticide research and monitoring is provided, including research contracts and grants. Cooperation with other governmental agencies is authorized for research and monitoring purposes. A National Monitoring Plan is required to be formulated and carried out by the Administrator.

Section 21. Solicitation of Comments; Notice of Public Hearings

1. The Administrator is required to solicit the views of the Secretary of Agriculture before publishing regulations under the Act.
2. The Administrator is authorized to solicit the views of all interested persons concerning any action under the Act and seek advice from qualified persons.
3. Timely notice of any public hearing to be held shall be published in the Federal Register.

Section 22. Delegation and Cooperation

1. The Administrator may delegate his authority under the Act.
2. The Administrator shall cooperate with appropriate governmental agencies in order to carry out the Act.

Section 23. State Cooperation, Aid, and Training

1. The Administrator may delegate to a State the authority to cooperate in enforcement of the Act, train State personnel in cooperative enforcement, and assist States to implement co-operative enforcement with grants.
2. The Administrator may assist States in developing and administering applicator certification programs under cooperative agreements and under contracts.
3. The Administrator may utilize the Cooperative State Extension Services to inform farmers of measures taken under the Act.

Section 24. Authority of States

1. A State may impose greater regulation on the sale or use of a pesticide than that of the Federal Government. However, different State packaging or labeling requirements are prohibited.
2. A State certified by the Administrator may register pesticides formulated for distribution and use within its bounds, and the registration is permanent if not disapproved by the Administrator within 90 days.

Section 25. Authority of the Administrator

1. The Administrator may exempt from the Act pesticides which do not require regulation, or are adequately regulated under other Federal law.
2. The Administrator is authorized to declare that which is a pest; determine highly toxic substances in pesticides; specify classes of devices subject to certain misbranding provisions and Section 7; prescribe pesticide discoloration requirements; and determine suitable pesticide names.

Section 26. Severability

The Act is severable in that the invalidity of one provision would not invalidate the remaining provisions.

Section 27. Authorization for Appropriations

Such sums as are necessary are authorized to be appropriated through June 30, 1975, and thereafter as provided by new legislation.

KEY POINTS THAT AFFECT THE APPLICATOR

1. In general, the Act will divide pesticides into 2 classifications. These will be termed General Use and Restricted Use. At the time pesticides are registered, EPA will decide whether the use will be classified as general or restricted. EPA makes it clear that the classification will be by pesticide use, not by the chemical pesticide per se.

   If a pesticide, when used in accordance to directions, will not harm the environment to an unreasonable degree, it can be classified as general use. But if it could harm the environment or the applicator, even when used as directed, it will be classified as restricted use.

2. The Act also sets the standards for what must appear on the label, directions for use, container disposal, first aid instructions and environmental warnings (refer to section on labeling).

3. It prohibits the applicator whether certified or not from using a pesticide in any manner other than that directed on the label. This means that if a pesticide is not registered to control a certain pest, it cannot be used for the control of that pest. It also means that the manner of application specified on the label must be adhered to. Example: if the label does not specify use in a fogging device, this means the pesticide is not to be fogged. The Act also provides that the label specify the rate of application. If the label states that it is to be used at the rate of a specified number of gallons to a given area, then to use the pesticide at a higher or lower rate other than that on the label would be a violation.

4. If an operator violates the Act, he may be subject to either civil or criminal penalties. He may be subject to a civil penalty of as much as $5,000 for each offense if he violates the Act unintentionally. If he knowingly or deliberately violates the Act, he may be fined up to $25,000 or sentenced to prison for one year or both.

5. Although F.D.A. regulates the safe amounts of pesticides (residues) that may remain on foods, E.P.A. sets these tolerances when the pesticide use is registered.

6. Probably the most important provision of the Act calls for the certification of all applicators who apply restricted use pesticides.

Environmental and human health problems associated with the use and misuse of pesticides can be divided into several categories among which are acute impact on human health, localized environmental effects and potential long-term health effects, i.e., environmental effects extending beyond the immediate pesticide application site. Acute health effects and localized environmental effects are largely associated with the improper handling and use of pesticides by the individual applicator. Certification can be a basis for ensuring that pesticide users have sufficient practical knowledge to protect themselves and others from acute health effects and to prevent the most common types of localized environmental damage. The proposed standards require such knowledge for certification.

The other problems are associated with the extent of use by all applicators and the characteristics of pesticides, for example, mobility, persistence, and tendency to bioaccumulate in the food chain. There is obviously some overlap. For example, pesticide runoff into streams can create a localized water contamination problem and also contribute to wide-spread environmental contamination.

The exact impact of applicator certification on the problems of potential long-term health effects and widespread environmental effects is unknown. However, it is apparent that certification can have some impact. For example application techniques and precautions which minimize acute health hazards reduce some of the hazards associated with repeated applications and chronic exposure. Since the certification standards stress a practical knowledge of pesticide usage, a certified applicator should be cognizant of application techniques which can mitigate these environmental effects. The additive effect of good practices by more responsible applicators can be expected to lessen the possibility of protracted undesirable effects.

However, it is clear that the certification alone is not adequate to prevent long-term human health and widespread environmental problems. Applicators generally have less reason to consider the widespread environmental effects of a particular application than to protect themselves and others from being poisoned. Even more important, an individual applicator normally is never in a position to control total usage of a given pesticide in a specific area during a growing season. To meet these problems Congress provided other regulatory mechanisms in the FIFRA as amended.

The categories discussed in the following sections have been established by E.P.A. for commercial applicators of pesticides. The states shall adopt these categories as needed, along with such other categories or sub-categories as needed. Some of the states have grouped the applicators of pesticides for the control of structural pests into one category. Others have established several groups for licensing purposes and may find it necessary to establish sub-categories to meet their particular requirements.

It is EPA's position that sophisticated academic training should not be necessary to equip an applicator to do such things as identify common types of pests, comprehend instructions and warnings on a pesticide label, make the calculations necessary to arrive at a proper dilution of the product, calibrate application equipment, identify and avoid situations that obviously will result in injury to non-target species, make proper use of protective clothing, and keep pesticide containers out of children's reach.

In developing the proposed standards, EPA considered the following alternatives in defining the nature and scope of problems applicator certification should meet:

1. Applicator certification should be designed to ensure competence with respect to prevention not only of acute health effects and localized environmental damage, but also long-term health hazards and widespread environmental problems.
2. Applicator certification should be mainly designed to ensure competence with respect to prevention of acute human health effects and localized environmental problems.

EPA also considered the following alternatives in defining the level of knowledge that an applicator should be expected to have:

1. Academic level. Full comprehension of the principles and practices of pest control, plus practical knowledge of pesticide application techniques and problems.
2. Operational level. Practical knowledge of pest problems, environmental and health concerns, and application techniques and precautions.

Based on the considerations outlined above, the latter alternative was adopted in each case. The proposed standards are written in such a way as to require certified applicators to have practical knowledge relevant to prevention of acute health effects and localized environmental contamination. This approach is the one most directly related to the ways in which applicator certification can mitigate the problems arising from improper use of pesticides. At the same time, it ensures that pesticide application will be increasingly in the hands of well trained, more responsible people. The former alternative would require a more comprehensive and sophisticated certification program without necessarily having any greater impact on the environmental hazards.

EPA certification of applicators who apply toxic pesticides fall into the following categories:

Agricultural Pest Control

Plant

This category includes commercial applicators using or supervising the use of restricted use pesticides in production of agricultural crops, including without limiting the foregoing, tobacco, peanuts, cotton, feed grains, soybeans forage, vegetables, small fruits and nuts, as well as on grasslands and non-crop agricultural lands.

Animal

This category includes commercial applicators using or supervising the use of restricted use pesticides on animals, including without limiting the foregoing, beef cattle, dairy cattle, swine, sheep, horses, goats, poultry, and livestock, and to places on or in which animals are confined. Doctors of veterinary medicine engaged in the business of applying pesticides for hire, publicly holding themselves out as pesticide applicators, or engaged in large-scale use of pesticides are included in this category.

Forest Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides in forests, forest nurseries, and forest seed producing areas.

Ornamental and Turf Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides to control pests in the maintenance and production of ornamental trees, shrubs, flowers, and turf.

Seed Treatment

This category includes commercial applicators using or supervising the use of restricted use pesticides on seeds.

Aquatic Pest Control

This category includes commercial applicators using or supervising the use of any restricted use pesticide purposefully applied to standing or running water, excluding applicators engaged in public health related activities including the category of public health pest control.

Right-of-Way Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides in the maintenance of public roads, electric powerlines, pipelines, railway rights-of-way or other similar areas.

Industrial, Institutional, Structural and Health Related Pest Control

This category includes commercial applicators using or supervising the use of restricted use pesticides in, on, or around food handling establishments, human dwellings, institutions such as schools and hospitals, industrial establishments, including warehouses and grain elevators, and any other structures and adjacent areas, public or private; and for the protection of stored, processed, or manufactured products.

Regulatory Pest Control (Not in Arizona)

This category includes State, Federal or other governmental employees who use or supervise the use of restricted use pesticides in the control of regulated pests.

Demonstration and Research Pest Control (Not in Arizona)

This category includes individuals who demonstrate to the public the proper use and techniques of application of restricted use pesticides or supervise such demonstration, and persons conducting field research with pesticides, and in doing so, use or supervise the use of restricted use pesticides. Included in the first group are such persons as extension specialists and county agents, commercial representatives demonstrating pesticide products, and those individuals demonstrating methods used in public programs. The second group includes state, federal, commercial and other persons conducting field research on or utilizing restricted use pesticides.

Other Categories and Subcategories

Any state submitting a plan pursuant to this section for the certification of applicators, as provided for below, may designate such subcategories within the above 10 categories as it deems necessary. In addition, a state may delete a category not needed or may request the Administrator's approval of additional major categories.

DETERMINATION OF COMPETENCY

Competence in the use and handling of pesticide shall be determined on the basis of written examinations, and, as appropriate, performance testing, based upon standards set forth below and which are approved by the Administrator. Such examination and testing shall include the general standards applicable to all categories and the additional standards specifically identified for each category or subcategory (if any) in which an applicator is to be classified. State standards must conform and be at least equal to those prescribed herein. In developing the details of standards at the state level and in structuring examinations, it is important to recognize and reflect the extent of competency appropriate and necessary to a particular category.

General Standards for All Categories of Certified Commercial Applicators

All commercial applicators shall demonstrate practical knowledge of the principles and practices of pest control and safe use of pesticides. Testing shall be based on examples of problems and situations appropriate to the particular category or subcategory of the applicator's certification and the following areas of competency:

Label and Labeling Comprehension

1. The general format and terminology of pesticide labels and labeling.
2. The understanding of instructions, warnings, terms, symbols and other information commonly appearing on pesticide labels.
3. Classification of the product, general or restricted.
4. Necessity for use consistent with the label.

Safety

Factors including:

1. Pesticide toxicity and hazard to man and common exposure routes.
2. Common types and causes of pesticide accidents.
3. Precautions necessary to guard against injury to applicators and other individuals in or near treated areas.
4. Need for and use of protective clothing and equipment.
5. Symptoms of pesticide poisoning.
6. First aid and other procedures to be followed in case of a pesticide accident.
7. Proper identification, storage, transport, handling, mixing procedures and disposal methods for pesticides and used pesticide containers, including precautions to be taken to prevent children from having access to pesticides and pesticide containers.

Environment

The potential environmental consequences of the use and misuse of pesticides as may be influenced by such factors as:

1. Weather and other climatic conditions.
2. Type of terrain, soil or other substrate.
3. Presence of fish, wildlife and other non-target organisms.
4. Drainage patterns.

Pests

Factors such as:

1. Common features of pest organisms and characteristics of damage needed for pest recognition.
2. Recognition of relevant pests.
3. Pest development and biology as it may be relevant to problem identification and control.

Pesticides

Factors such as:

1. Types of pesticides.
2. Types of formulations.
3. Compatibility, synergism, persistence and animal and plant toxicity of the formulations.
4. Hazards and residues associated with use.
5. Factors which influence effectiveness or lead to such problems as resistance to pesticides.
6. Dilution procedures.

Equipment

Factors including:

1. Types of equipment and advantages and limitations of each type.
2. Uses, maintenance and calibration.

Application Techniques

Factors including:

1. Methods of procedure used to apply various formulations of pesticides, solutions, and gases, together with a knowledge of which technique of application to use in a given situation.
2. Relationship of discharge and placement of pesticides to proper use, unnecessary use, and misuse.
3. Prevention of drift and pesticide loss into the environment.

Laws and Regulations

Applicable state and federal laws and regulations.

Specific Standards of Competency for Each Category of Commercial Applicators

Some of the factors of this section are of particular importance because of the different types of activities carried out by applicators in each category. Such factors must be especially stressed and specifically reflected in state certification standards, as appropriate. For example, practical knowledge of drift problems should be required of agricultural applicators but not of seed treatment applicators. The latter, however, should be particularly knowledgeable of the hazards of the misuse of treated seed and the necessary precautionary techniques. Many applicators (especially public health, regulatory and demonstration and research) will have had considerable formal education, training and experience in preparation for their positions. Their competency with respect to the use and handling of pesticides will have been determined by examining boards of their professional scientific societies utilizing standards which equal or exceed those prescribed herein. Such standards should be consulted by states in developing their state standards for certification of such applicators under these regulations. Commercial applicators in each category shall be particularly qualified with respect to the practical knowledge standards elaborated below:

Agricultural Pest Control

Plant

Applicators must demonstrate practical knowledge of crops grown and the specific pests of those crops on which they may be using restricted use pesticides. The importance of such competency is amplified by the extensive areas involved, the quantities of pesticides needed, and the ultimate use of many commodities as food and feed. Practical knowledge is required concerning soil and water problems, pre-harvest intervals, re-entry intervals, phytotoxicity, and potential for environmental contamination, non-target injury and community problems resulting from the use of restricted use pesticides in agricultural areas.

Animal

Applicators applying pesticides directly to animals must demonstrate practical knowledge of such animals and their associated pests. A practical knowledge is also required concerning specific pesticide toxicity and residue potential, since host animals will frequently be used for food. Further, the applicator must know the relative hazards associated with such factors as formulation, application techniques, age of animals, stress and extent of treatment.

Forest Pest Control

Applicators shall demonstrate practical knowledge of types of forests, forest nurseries, and seed production in their state and the pests involved. They should possess practical knowledge of the cyclic occurrence of certain pests and specific population dynamics as a basis for programming pesticide applications. A practical knowledge is required of the relative biotic agents and their vulnerability to the pesticides to be applied. Because forest stands may be large and frequently include natural aquatic habitats and harbor wildlife, the consequences of pesticide use may be difficult to assess. The applicator must therefore demonstrate practical knowledge of control methods which will minimize the possibility of secondary problems such as unintended effects on wildlife. Proper use of specialized equipment must be demonstrated, especially as it may relate to meterological factors and adjacent land use.

Ornamental and Turf Pest Control

Applicators shall demonstrate practical knowledge of pesticide problems associated with the production and maintenance of ornamental trees, shrubs, plantings, and turf, including cognizance of potential phytotoxicity due to a wide variety of plant material, drift, and persistence beyond the intended period of pest control. Because of the frequent proximity of human habitations to application activities, applicators in this category must demonstrate practical knowledge of application methods which will minimize or prevent hazards to humans, pets, and other domestic animals.

Seed Treatment

Applicators shall demonstrate practical knowledge of types of seeds that require chemical protection against pests and factors such as seed coloration, carriers, and surface active agents which influence pesticide binding and may affect germination. They must demonstrate practical knowledge of hazards associated with handling, sorting and mixing, and misuse of treated seed such as introduction of treated seed into food and feed channels, as well as proper disposal of unused treated seeds.

Aquatic Pest Control

Applicators shall demonstrate practical knowledge of the secondary effects which can be caused by improper application rates, incorrect formulations, and faulty application of restricted use pesticides used in this category. They shall demonstrate practical knowledge of various water use situations and the potential of downstream effects. Further, they must have practical knowledge concerning potential pesticide effects on plants, fish, birds, beneficial insects and other organisms which may be present in aquatic environments. These applicators shall demonstrate practical knowledge of the principles of limited area application.

Right-of-Way Pest Control

Applicators shall demonstrate practical knowledge of a wide variety of environments, since rights-of-way can traverse many different terrains, including water-ways. They shall demonstrate practical knowledge of problems on runoff, drift, and excessive foliage destruction and ability to recognize target organisms. They shall also demonstrate practical knowledge of the nature of herbicides and the need for containment of these pesticides within the right-of-way area, and the impact of their application activities in the adjacent areas and communities.

Industrial, Institutional, Structural and Health Related Pest Control

Applicators must demonstrate a practical knowledge of a wide variety of pests, including their life cycles, types of formulations appropriate for their control, and methods of application that avoid contamination of food, damage and contamination of habitat, and exposure of people and pets. Since human exposure, including babies, children, pregnant women, and elderly people, is frequently a potential problem, applicators must demonstrate practical knowledge of the specific factors which may lead to a hazardous condition, including continuous exposure in the various situations encountered in this category. Because health related pest control may involve outdoor applications, applicators must also demonstrate practical knowledge of environmental conditions, particularly related to this activity.

Public Health Pest Control

Applicators shall demonstrate practical knowledge of vector-disease transmission as it relates to and influences application programs. A wide variety of pests is involved, and it is essential that they be known and recognized, and appropriate life cycles and habitats be understood as a basis for control strategy. These applicators shall have practical knowledge of a great variety of environments ranging from streams to those conditions found in buildings. They should also have practical knowledge of the importance and employment of such non-chemical methods as sanitation, waste disposal, and drainage.

The above Standards Do Not Apply to the Following Persons For Purposes of These Regulations

1. Persons conducting laboratory type research involving restricted use pesticides
2. Doctors of Medicine and Doctors of Veterinary Medicine applying pesticides as drugs or medication during the course of their normal practice.

Standards for Certification Of Private Applicators (Agricultural Only)

1. Competence in the use and handling of pesticides by a private applicator will be determined by procedures set forth below. State standards must comform and be at least equal to those prescribed herein. As a minimum requirement for certification, a private applicator must show that he possesses a practical knowledge of the pest problems and pest control practices associated with his agricultural operations; proper storage, use, handling and disposal of the pesticides and containers; and his related legal responsibility. This practical knowledge includes ability to -

    a. Recognize common pests to be controlled and damage caused by them.
    b. Read and understand the label and labeling information - including the common name of pesticides he applied; pest (s) to be controlled, timing and methods of application; safety precautions; any pre-harvest or re-entry restrictions; and any specific disposal procedures.
    c. Apply pesticides in accordance with label instructions and warnings, including the ability to prepare the proper concentration of pesticide to be used under particular circumstances taking into account such factors as area to be covered, speed at which application equipment will be driven, and the quantity dispersed in a given period of operation.
    d. Recognize local environmental situations that must be considered during application to avoid contamination.
    e. Recognize poisoning symptoms and procedures to follow in case of a pesticide accident.

Such competence of each private applicator shall be verified by the responsible State agency through the administration of a private applicator certification system which ensures that the private applicator is competent, based upon the standards set forth above, to use the restricted use pesticides under limitations of applicable state and federal laws and regulations. A certification system shall employ a written or oral testing procedure, or such other equivalent system as may be approved as part of a state plan.

1. In any case where a person, at the time of testing for certification, is unable to read a label, the responsible State agency may employ a testing procedure, previously approved by the Administrator, which can adequately assess the competence of such person with regard to all of the above standards. Certification must be related and limited to the use and handling of each individual pesticide for which he desires certification at any time. Therefore, the applicator will be authorized to use only the pesticide (s) for which he has demonstrated competence.
2. A specific procedure is required (171.5a) relating to label comprehension, with testing designed to assure his knowledge of the following:

    a. Understanding of the label and labeling information including those items indicated in that subsection.
    b. Sources of advice and guidance necessary for the safe and proper use of each pesticide related to his certification.

PROPOSED REGULATIONS FOR PROHIBITION OF CERTAIN ACTS REGARDING DISPOSAL AND STORAGE

Pesticides and Pesticide Containers

The Federal Insecticide, Fungicide and Rodenticide Act, as amended by the Federal Environmental Pesticide Control Act of 1972 (FIFRA, as amended) (86 Stat. 973, PL 92-516) requires the Administrator of the US Environmental Protection Agency (the Agency) to establish regulations and procedures for the disposal and storage of pesticides and their containers.

While the basic thrust of the FIFRA, as amended, is to regulate the registration, labeling, and application of pesticides, a primary goal of the Act is the "protection of health and the environment," which is defined to mean "protection against any unreasonable adverse effects on the environment." The Agency has determined that some methods of pesticide disposal and storage are so likely to cause unreasonable adverse effects on health or the environment that the best form of regulation is to prohibit such acts. These worst acts include open burning (unless undertaken by the user in small quantities in open fields), open dumping, water dumping (except as may be provided for by regulations issued pursuant to sections 304, 307, 311, 402, and 404 of the Federal Water Pollution Control Act Amendments of 1972), ocean dumping (except as may be permitted by regulations developed under the Marine Protection, Research, and Sanctuaries Act of 1972), storage in such a manner as to cause contamination of food or feed supplies, and well injection without adequate testing to assure environmental protection.

STATE LAWS AND REGULATIONS

Brief Synopsis of the Arizona Statutes Rules and Regulations

No person, partnership, corporation or association shall engage in the business of Urban and Structural Pest Control without being licensed by a Structural Pest Control Board.

Structural Pest Control is defined as control of household pest, wood-destroying pests or organisms, or other pests which may invade households or other structures, including railroad cars, boats, docks, trucks, airplanes or the contents thereof, or pests including weeds, which exist in the area around structures, in lawns or ornamental shrubs and trees.

A license must be possessed to make identifications of infestations or infections, offering to engage in pest control, advertising or soliciting to perform pest control. A license must also be possessed to make inspection reports, recommendations, estimates and/or bids, whether written or oral or for the purpose of submitting bids for the use of insecticides, pesticides, rodenticides, fumigants, herbicides or allied substances including mechanical devices for the purpose of controlling or preventing infestations or infections of any pest in or around structures.

The Board is composed of 5 members; 2 must represent the public and be well versed in structural pest control practices or allied fields. The other 3 must have been in the pest control practice, in Arizona, for at least the past 5 years. A member is appointed each year by the Governor for a term of 5 years; however, no member may serve more than 2 consecutive terms. A majority of the Board constitutes a quorum; however, at least 1 member of such quorum must be a member representing the public. All Board meetings are open to the public except executive sessions.

The Board has the power to cause or make investigations, compel attendance, administer oaths and take testimony concerning all matters within its jurisdiction. The Board may adopt reasonable rules and regulations necessary to carry out its duties under the Statutes.

The maximum fees are as follows: application or examination for registration, $100; registration or annual renewal, $100.

Persons not required to be licensed

1. Those engaged only in agriculture pest control work and licensed or supervised by the Board of Pesticide Control.
2. Those that perform pest control on property which they own, lease or rent;
3. Governmental Agencies, State, Federal, City or County officials when officially engaged;
4. Any educational institution or State agency engaged in research or study of pest control.

Applications for examination or licensing must be on forms as prescribed by the Board and must contain not less than the name and address of the applicant. If the applicant for license is a partnership, corporation or association, the name of the responsible person to be licensed on behalf of such entity must be on the application. Should the responsible person of any firm or entity become disassociated with the Arizona operation of said firm or entity for any reason, the firm or entity has 90 days from such disassociation to make application for the licensing of another responsible person.

Each applicant must satisfy the Board of his character, responsibility, good faith and that he is qualified to carry out the business of structural pest control.

The Board may by examination, oral or written, determine the individual's knowledge of structural pest control and his knowledge of the use, storage and application of chemicals and other devices used in the field of pest control.

Examination and license may be applied for in one or any combination or all of the following classifications:

1. General Pest Control;
2. Control of Wood-Destroying Organisms;
3. Weed Control;
4. Fumigation;
5. Horticultural Pest Control.

The Board by rule may establish other classifications. All licenses are issued for a calendar year and are renewable annually. There are no provisions for a temporary license or work permit.

All licensed entities must furnish the Board with financial proof protecting persons who may suffer legal damages as a result of the pest control operations of the licensee. Financial proof may consist of either a deposit of money, liability insurance, surety bond or certified check and the amount of such financial responsibility shall not be less than $25,000 for property damage, and a like amount for public liability.

The Board may revoke, suspend or refuse to renew any license if the Board finds the licensee has committed any of the following acts:

1. Operating a business in a faulty, careless or negligent manner.
2. Refusing or neglecting to comply with the Law, Rules and Regulation or any lawful order of the Board.
3. Making false or fraudulent records or report.
4. Misrepresentation by the applicant in obtaining a license.
5. Willful failure to fulfill the terms of a contract or agreement.
6. Commission of any grossly negligent or fraudulent act while engaged in the pest control business.
7. Negligent handling or use of any chemical or device without due respect to public safety.
8. Making any false statements, or misrepresentations concerning his business through any material.
9. Conviction of a felony or misdemeanor in connection with the operation of his business.
10. Adjudication of bankruptcy.

Violations of the statute is considered a misdemeanor punishable by a fine of not more than $300, by imprisonment in the County Jail not to exceed 60 days or both.

Licensees must, in the course of their business, use the name as licensed. A license may be associated with only one business entity at one time. Licenses are not transferable and only can be legally used by the person to whom it is issued.

Each licensee must make and preserve reasonable records for a period of 2 years of work performed. Whenever there is any representation of wood-destroying pests in existing structures, the record must consist of not less than a written description stating the nature and location of any infestation and/or damage.

When a licensee changes his business or residence location he must notify, by registered or certified mail, of such change within 10 days. If a license is included in a civil or criminal suit or complaint as a result of his pest control operation, he must notify the Board, by certified or registered mail, the nature of such suit or complaint within 10 days from receipt of notice of such suit or complaint.

All vehicles, other than management vehicles not used exclusively in selling or soliciting pest control work, must be identified on both sides of the vehicle; showing the licensed name, license number and category. Such identification must be prominently displayed in contrasting color to background color in letters and numerals not less than 2 inches in height.

Except in tanks, from which it will be directly discharged, all chemicals on vehicles must be kept under lock and key. Yard or office storage facilities of chemicals must be in compliance with all political subdivisions building and zoning requirements.

Fumigation must be done while a person fully competent is present. Proper and effective gas mask must be available on the job. Each side of each building and entrance or exit way must have fumigant warning signs posted. Each building must be inspected for the presence of humans or domestic pets prior to injection of fumigant. A licensee may not use or possess any fumigant unless he in fact is licensed to do fumigation.

All pest control must be done under the supervision of the person licensed by the Board. "Supervision" means that a pesticide is applied by a competent person acting under the instructions and control of a licensed person who is available if and when needed, even though such licensed person is not physically present at the time and place the pesticide is applied.

Synopsis of Arizona State Law (Certification)

"Act" means the Federal Environmental Pesticide Control Act of 1972 and "Administrator" means the head of the Environmental Protection Agency of the United States.

A "Restricted Use Pesticide" is one that has been defined as having the properties that may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator.

"Structural Commercial Applicator" is a person who uses or supervises the use of any restricted use pesticide.

"Under the direct supervision of" means that, unless otherwise prescribed by the label of a particular pesticide, a pesticide is applied by a competent person acting under the instructions and control of a certified applicator who is available if and when needed, even though such certified applicator is not physically present at the time and place the pesticide is applied.

"Unreasonable adverse effects on the environment" means any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide.

The Board may adopt Rules and Regulations which shall include, but are not limited to -

1. Categorization of applicators for certification
2. Standards for certification of applicators within the various categories
3. Standards for supervision on non-certified applicators by certified Structural commercial applicators
4. Requirements that applicators keep records.

The Board may investigate alleged violations of the Act, State Law, Rules and Regulations or its orders or any of the Rules and Regulations promulgated by the Environmental Protection Agency.

The Board may require examinations and other demonstrations of competence prior to certification.

The Board may enter into cooperative agreement with Federal and/or State agencies for the purpose of certification and enforcement of the State Program.

After October 21, 1977, no one may apply a restricted pesticide unless that person is certified or acting under the direct supervision of a certified person.

Certification of applicants will be done by the Board and each certification is for a period of one year and each certification may be renewed yearly.

The Board has the power to refuse certification, revoke or suspend certification for reason or cause which may be, but are not limited to the following:

1. Violation of any of the provisions of the Act or any of its Rules and Regulations
2. Violation of any of the Rules and Regulations of the Board.
3. Violation of any condition imposed by the Board in connection with a certification.

Violations, civil penalty, are punishable by a fine not to exceed $1,000. Violations, criminal penalty, not more than $300 or imprisoned for not more than 6 months, or both.

Injunctions for violation of any Article or Rule, Regulation or order of the Board may be sought and issued upon any firm found guilty of such violation.

The Board or any of its duly authorized agents may enter with warrant any private or public property where it has reason to believe any restricted use pesticides are being used or stored, for the purpose of inspecting and investigating conditions relating to the use and application of restricted pesticides.

TERMS USED IN PEST CONTROL

In the field of pest control, superintendents are confronted with more and more scientific and technical terms. This section has been designed to give you a better understanding of the terms often found in pest control publications and a ready reference.

Abrasion - The process of wearing away by rubbing

Abscission - The separation of fruit, leaves, or stems from a plant

Absorption - The process by which a chemical is taken into plants, animals, or minerals. Compare with adsorption

Analogue - A compound that is very similar in both structure and formula to another compound

Animal Sign - The evidences of an animal's presence in an area

Annual - A plant that completes its life cycle in one year or growing season

Antagonism - The loss of activity of a chemical when exposed to another chemical

Antibiotic - A substance which is used to control pest microorganisms

Anti-Dessicant - A material that prevents or reduces the rate a plant dries out

Antidote - A practical, immediate treatment including first aid in case of poisoning

Acid Equivalent - The amount of active ingredient expressed in terms of the parent acid

Activator - A material used to increase the effectiveness of the active ingredient

Active Ingredient - The actual toxic material (s) present in a formulation

Acute LD_{50} - In toxicity studies it is the dosage required to kill 50 percent of the test animals when given a single dosage. The dosage is expressed by the weight of the chemical per unit of body weight; for example, milligrams per kilogram (mg/kg)

Additive - Any material that is added to a pesticide (not necessarily a wetting agent or a surfactant)

Adhesive - A substance that will cause a spray material to stick to the sprayed surface; e.g., sticking agent, spreadersticker, etc.

Adjuvant - A substance combined with spray materials to act as wetting or spreading agents, stickers, penetrants, emulsifiers, etc., aiding in the action of the toxic materials

Adsorption - The process by which chemicals are held on the surface of a mineral or soil particle. Compare with absorption

Adulterated - Any pesticide whose strength or purity falls below the quality stated on its label. Also, a food, feed, or product that contains illegal pesticide residues

Aerobic - Living in air. The opposite of anaerobic

Aerosol - An extremely fine mist or fog consisting of solid or liquid particles suspended in air. Also, certain formulations used to produce a fine mist

Agitation - The process of stirring or mixing in a sprayer

Alkaloids - Chemicals present in some plants. Some are used as pesticides

Amine - An organic compound containing nitrogen derived from ammonia

Anaerobic - Living in the absence of air. The opposite of aerobic

Aqueous - A term used to indicate the presence of water in a solution

Arsenicals - Pesticides containing arsenic

Aseptic - Free of desease-causing organisms

Aquatic - A plant that grows in water

Atomize - To break up a liquid into fine droplets by passing it through an apparatus under pressure

Bait Shyness - The tendency for rodents, birds, or other pests to avoid a poison bacteria

Biennial - A plant that completes its life cycle within 2 years. The first year it produces leaves and stores food while the second year it produces seed.

Biological Control - Controlling a pest by its natural or introduced enemies.

Bipyridyliums - A group of synthetic organic pesticides which includes the herbicide paraquat

Botanical Pesticide - A pesticide made from plants. Also called plant-derived pesticides

Broadcast Application - Distributing the chemical over the entire area

Broadleaf Plants - Plants with broad leaves, usually with fleshy roots as distinct from the grasses

Broadleaf Weeds - Plants with broad, rounded, or flattened leaves

Brush Control - Control of woody plants

Carbamate - A synthetic organic pesticide containing carbon, hydrogen, nitrogen, and sulfur

Carcinogenic - Can cause cancer

Carrier - The inert liquid or solid material added to an active ingredient to prepare a pesticide formulation

Causal Organism - The organism (pathogen) that produces a specific desease

Chemosterilant - A chemical that can prevent reproduction

Chlorinated Hydrocarbon - A synthetic organic pesticide that contains chlorine, carbon, and hydrogen. Same as organochlorine

Chlorosis - The yellowing of a plant's green tissue

Cholinesterase - A chemical catalyst (enzyme) found in animals that helps regulate the activity of nerve impulses

Compatible - When two or more chemicals can be mixed without affecting each other's properties, they are said to be compatible

Concentration - The amount of active ingredient in a given volume or weight of formulation

Contact Herbicide - A plant killer that affects only the parts of the plant it falls upon

Contaminate - To make impure or to pollute

Control - The process of limiting infestations to a point where only acceptable losses will occur

Corrosion - The process of wearing away by chemical means

Creeping Perennial - A perennial plant that spreads by asexual means of lateral stems. (rhizomes, stolons, etc.)

Crucifers - Plants belonging to the mustard family, such as mustard, cabbage, turnip, and radish

Cucurbits - Plants belonging to the gourd family, such as pumpkin, cucumber, and squash

Deciduous Plants - Perennial plants that lose their leaves during the winter

Deflocculating Agent - A substance that prevents rapid settling out of the spray solution in the spray tank

Defoliant - A chemical that causes the leaves to fall off a plant

Degradation - The process by which a chemical is reduced to a less complex form

Dermal Toxicity - A measure of the amount of a poisonous compound that can be absorbed through the skin in sufficient quantity to produce toxic symptoms

Desiccant - A compound that will cause a plant to dry out

Detergent - Any soap or synthetic water soluble or liquid organic compound that can emulsify oils and/or hold particles in suspension

Dicot - A plant having two seed leaves or cotyledons. Generally refers to broadleaf plants

Diluent - Any liquid or solid material used to dilute or carry an active ingredient

Dilute - To make thinner by adding water, another liquid or a solid

Dispersing Agent - A material that reduces the attraction between particles

Dormant - State in which growth of seeds or other plant organs stops temporarily

Dose, Dosage - Quanity of a pesticide applied

Drift - The movements of spray particles or fumes outside the intended target area

Dust (D) - Any chemical existing as extremely fine, dry particles

Emergence - Refers to the time when the shoot of a plant appears above the soil surface

Emulsifiable Concentrate (EC) - A surface active material which facilitates the suspension of one liquid in another

Emulsion - A mixture of one liquid in another

Eradication - Elimination of living organisms from a specified area

Ester - A compound formed by the reaction between an acid and an alcohol or phenol

Formulation - The form in which active ingredients of a pesticide and carriers are mixed, packaged and sold (i.e., WP, G, etc.)

Fumigant - A material in the gas or vapor form that destroys organisms

Fungistat - A chemical that keeps fungi from growing

GPA - Gallons per acre

GPM - Gallons per minute

Germination - The evidence of growth initiation by development beyond seed coverings

Granules (G) - Formulations in which the active ingredient is impregnated on or in an inert solid carrier

Growth Regulator - Compounds that regulate growth and metabolic processes of organisms

Growth Stages of Cereal Crops - (1) Tillering-when additional shoots are developing from the flower buds. (2) Jointing-when stem internodes begin elongating rapidly. (3) Booting-when upper leaf sheath swells due to the growth of developing spike or panicle. (4) Heading-when seed head is emerging from the upper leaf sheath

Hard (water) - Water containing soluble salts of calcium and magnesium and sometimes iron

Herbaceous - Referring to plants with non-woody stems that normally die completely or die back to the ground in the winter

Herbaceous Plant - A plant that does not develop wood, tissue

Herbicide - Any compound used to kill or inhibit the growth of a plant

Hormone - Regulators produced by plants or synthetically which, in low concentration, regulate plant physiological processes

Host - The living plant or animal a pest depends on for survival

Hydrogen-Ion Concentration - A measure of acidity or alkalinity, expressed in terms of the pH of the solution. For example, a pH of 7 is neutral from 1 to 7 is acid, and from 7 to 14 is alkaline

Immune - Not susceptible to a disease or poison

Impermeable - Cannot be penetrated. Semipermeable means that some substances can pass through and others cannot

Infested - Occurrence of a large number of similar or dissimilar organisms in a particular area

Lactation - The production of milk by an animal, or the period during which an animal is producing milk

Larva - The early form of an insect from the time that it leaves the egg until it becomes a pupa

LC_{50} - The concentration of an active ingredient in air which is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas, or vapor. It is generally expressed as micrograms per liter as a dust or mist but in the case of a gas or vapor as parts per million (ppm)

LD_{50} - The dose of an active ingredient taken by mouth or absorbed by the skin which is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD_{50} of 10 milligrams per kilogram (mg/kg) it is more toxic than one having an LD_{50} of 100 mg/kg

Leaching - Movement of a substance downward or out of the soil as the result of water movement

Mammals - Warm-blooded animals that nourish their young with milk. Their skin is more or less covered with hair

Metamorphosis - A change in shape, form, and size in insects

Miscible Liquids - Two or more liquids that can be mixed and will remain mixed under normal conditions

Monocot - A plant having one seed leaf or cotyledon. Refers to grass-like leaves

MPH - Miles per hour

Mutagenic - Can produce genetic change

Necrosis - Localized death of living tissue such as the death of a certain area of a leaf

Necrotic - Showing varying degrees of dead areas or spots

Nitrophenols - Synthetic organic pesticides containing carbon, hydrogen, nitrogen, and oxygen

Nonselective Herbicide - A compound that kills any plant or parts of any plant it contacts

Noxious Weed - A plant defined as being especially undesirable or troublesome

Nutrient - A chemical element required by a plant in order to complete its life cycle

Nymph - The stage of development in certain insects after hatching. They look like the adult but lack fully developed wings

Oral - Of the mouth; through or by the mouth

Oral Toxicity - Ability of a pesticide to cause injury when taken by mouth

Organic Compounds - Chemicals that contain carbon

Organochlorine - Same as chlorinated hydrocarbon

Organophosphate - A synthetic organic pesticide containing carbon, hydrogen, and phosphorus; parathion and malathion are two examples

Overall Treatment - Applied uniformly over the entire area

Ovicide - A chemical that destroys eggs

Parasite - A plant or animal that lives on or in another plant or animal from which it gets food

Parts per Million (ppm) - The number of parts by weight or volume of a given compound in one million parts of the final mixture

Pathogen - Any disease-producing organism

Penetration - The act of entering or ability to enter

Percent Concentration - The weight or volume of a given compound in the final mixture expressed as a percentage

Perennial - A plant that lives for more than two years

Pest - Living things that compete with man for food and fiber, or attack man directly

Pesticide - Any chemical or mixture of chemicals used to control unwanted plant or animal life in order to protect desirable organisms

pH - A measure of alkalinity or acidity. (A pH of 7 is neutral, below is acid and above is alkaline)

Phytotoxicity - The effect of a chemical that causes death or injury to plants

Pollutant - An agent or chemical that makes something impure or dirty

PPB - Parts per billion. A way to express the concentration of chemicals in foods, plants, and animals. One part per billion equals 1 pound in 500,000 tons

PPM - Parts per million. A way to express the concentration of chemicals in foods, plants, and animals. One part per million equals 1 pound in 500 tons

Postemergence Herbicide - A chemical applied to plants after they emerge from the soil

Potentition - With respect to effects upon plants and animals, an undesirable increase in toxicity when two or more chemicals are combined

Precipitation - Settling-out of solid materials in a pesticide solution

Predator - An animal that destroys or eats other animals

Preemergence Herbicide - A chemical applied to living or dormant turf or at the time of seeding to kill weed plants as they germinate

Preplant Treatment - A chemical applied after the seedbed has been prepared but before planting of turf

Propellant - Liquid in self-pressurized pesticide products that forces the active ingredient from the container

PSI - Pounds per square inch

Pubescent - Having hairy leaves or stems

Pupa - The stage between the larva and adult in the development of some insects

Residual Herbicide - A weed killer that persists in the soil and kills plants as they germinate

Residue - That amount of chemical that is on or in a plant or in an animal at the time an analysis is made; also applies to soils

Resistance - The ability of an organism to withstand applications of normally harmful materials

Respiratory Tract - Having to do with or used for breathing; the lungs and other parts of the breathing system

Rhizome - A rootlike underground stem

RPM - Revolutions per minute

Safener - A chemical added to a pesticide to keep it from injuring plants

Seed Protectant - A chemical applied to seed before planting to protect seeds and new seedlings from disease and insects

Selective Herbicide - A compound that kills only certain varieties or species of plants

Slurry - A thick suspension of a finely divided substance in a liquid

Soil Fumigant - A compound which kills most organisms in the soil by vapor action

Soil Sterilant - A chemical that prevents the growth of all plants and animals in the soil. Soil sterilization may be temporary or permanent, depending on the chemical

Soluble - Will dissolve in a liquid

Solution - Mixture of one or more substances in another in which all ingredients are completely dissolved

Solvent - A liquid which will dissolve a substance to form a solution

Species - A group of individuals which are similar in structure and physiology and which are capable of interbreeding and producing fertile offspring which are like the parents

Spectrum - In agricultural chemical application, effective range of control of species

Spot Treatment - Application of a pesticide which is limited to only a small restricted area of infestation

Spreader - A chemical which increases the area that a given volume of liquid will cover on a solid or on another liquid

Sticker - A material added to a pesticide to increase its adherence

Stolon - An above-ground stem that produces roots

Summer Annuals - Plants which germinate in the spring, make most of their growth in the summer, and die in the fall after flowering and seeding

Surfactant - A chemical which increases the emulsifying, dispersing, spreading, and wetting properties of a pesticide product

Susceptible - Capable of being diseased or poisoned; not immune

Susceptible Species - A plant or animal that is poisoned by moderate amounts of a pesticide

Suspension - Finely divided solid particles mixed in a liquid

Synergism - The joint action of two or more pesticides that is greater than the sum of their activity when used alone

Systemic - A chemical which, when absorbed by the plant, moves throughout its whole system

Target Pest - The pest at which a particular pesticide or other control method is directed

Tillering Stage - When a plant starts producing additional shoots (tillers) from a single crown or crowns

Tolerance - (1) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes, or pesticides. (2) The amount of pesticide that may safely remain in or on raw farm products at time of sale

Toxicant - A poisonous chemical

Toxicity - The degree to which a chemical is poisonous

Trade Name - Same as brand name

Vapor Pressure - The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate

Vector - A carrier, such as an insect, that transmits a pathogen

Viscosity - A property of liquids that determines whether they flow readily. Viscosity usually increases when temperature decreases

Volatile - Evaporates at ordinary temperatures when exposed to air

Wettable Powder (WP) - A pulverized solid formulation which, when added to water, forms a suspension used for spraying

Wetting Agent - A material which, when added to spray solution, causes the spray to spread over and wet the plant surfaces more readily

Winter Annuals - Plants that germinate in the late summer, fall or winter, produce seed and die the next spring or early summer.

CONVERSION TABLES (U.S.)

Linear Measure -

1 foot - 12 inches
1 yard - 3 feet
1 rod - 5.5 yards -- 16.5 feet
1 mile - 160 rods -- 1760 yards -- 5280 feet

Square Measure -

1 square foot (sq. ft.) -- 144 square inches (sq. inch)
1 square yard (sq. yd.) -- 9 sq. feet
1 square rod (sq. rd.) -- 272.25 sq. ft. -- 30.25 sq. yd.
1 acre - 43560 sq. ft. -- 4840 sq. yds. -- 160 sq. rds.
1 square mile - 640 acres.

Cubic Measure -

1 cubic foot (cu.ft.) -- 1728 cubic inches (cu. in.) 29.922 liquid quarts = 7.48 gallons
1 cubic yard - 27 cubic feet

Liquid Capacity Measure -

1 tablespoon - 3 teaspoons
1 fluid ounce - 2 tablespoons
1 cup - 8 fluid ounces
1 pint - 2 cups -- 16 fluid ounces
1 quart - 2 pints -- 32 fluid ounces
1 gallon - 4 quarts -- 8 pints -- 128 fluid ounces

Weight Measure -

1 pound (lb.) - 16 ounces
1 hundred weight (cwt.) -- 100 pounds
1 ton - 20 cwt. -- 2000 pounds

Rates of Application -

1 ounce/sq. ft. -- 2722.5 lbs/acre
1 ounce/sq. yd. -- 302.5 lbs/acre
1 ounce/100 sq. ft. -- 27.2 lbs/acre
1 pound/100 sq. ft. -- 435.6 lbs/acre
1 pound/1000 sq. ft. -- 43.6 lbs/acre
1 gallon/acre -- 1/3 ounce/1000 sq. ft.
5 gallons/acre -- 1 pint/1000 sq. ft.
100 gallons/acre -- 2.5 gallons/1000 sq. ft. -- 1 quart/100 sq. ft.
100 lbs/acre -- 2.5 lbs/1000 sq. ft.

STANDARD MEASUREMENTS

Measure of Length (Linear Measure)

4 inches = 1 hand
9 inches = 1 span
12 inches = 1 foot
3 feet = 1 yard
6 feet = 1 fathom
5½ yards - 16½ feet = 1 rod
40 poles = 1 furlong
8 furlongs = 1 mile
5,280 feet = 1,760 yards = 320 rods = 1 mile
3 miles = 1 league

Measure of Surface (area)

144 square inches = 1 square foot
9 square feet = 1 square yard
30¼ square yards = 1 square rod
160 square rods = 1 acre
43,560 square feet = 1 acre
640 square acres = 1 square mile
36 square miles = 1 township

Surveyor's Measure

7.92 inches = 1 link
25 links = 1 rod
4 rods = 1 chain
10 square chains = 160 square rods = 1 acre
640 acres = 1 square mile
80 chains = 1 mile
1 Gunthers chain = 66 feet

Metric Length

1 inch = 2.54 centimeters
1 foot = .305 meter
1 yard = .914 meter
1 mile = 1.609 kilometers
1 fathom = 6 feet
1 knot = 6,086 feet
3 knots = 1 league
1 centimeter = .394 inch
1 meter = 3.281 feet
1 meter = 1.094 yards
1 kilometer = .621 mile

Troy Weight

24 grains = 1 pennyweight
20 pennyweight = 1 ounce
12 ounces = 1 pound

Liquid Measure

2 cups = 1 pint
4 gills = 1 pint
16 fluid ounces = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
31½ gallons = 1 barrel
2 barrels = 1 hogshead
1 gallon = 231 cubic inches
1 cubic foot = 7.48 gallons
1 teaspoon = .17 fluid ounces (1/6 oz.)
3 teaspoons (level) = 1 tablespoon (1/2 oz.)
2 tablespoons = 1 fluid ounce
1 cup (liquid) = 16 tablespoons (8 oz.)
1 teaspoon = 5 to 6 cubic centimeters
1 tablespoon = 15 to 16 cubic centimeters
1 fluid ounce = 29.57 cubic centimeters

Cubic Measure (Volume)

1,728 cubic inches = 1 cubic foot
27 cubic feet = 1 cubic yard
2,150.42 cubic inches = 1 standard bushel
231 cubic inches = 1 standard gallon (liquid)
1 cubic foot = 4/5 of a bushel
128 cubic feet = 1 cord (wood)
7.48 gallons = 1 cubic foot
1 bushel = 1.25 cubic feet

Dry Measure

2 pints = 1 quart
8 quarts = 1 peck
4 pecks = 1 bushel
36 bushels = 1 chaldron

Important Facts -

Volume of sphere - diameter ^{3} X .5236
Diameter -- circum. X .31831
Area of circle -- dia ^{2} X .7854
Area of ellipse -- prod. of both dia X .7854
Vol. of cone -- area of base X 1/3 ht.
1 cu. ft. water = 7.5 gallons = 62.5 lbs.
Pressure in psi -- ht. (ft.) X .434
1 acre = 209 feet square
ppm = % X 10,000
$\% = \frac{\text{ppm}}{10{,}000}$
1% by volume -- 10,000 ppm

TABLE OF CONVERSION FACTORS

To Convert From	To	Multiply By
Cubic feet	gallons	7.48
Cubic feet	liters	28.3
Gallons	milliliters	3785
Grams	pounds	.0022
Grams/liter	parts/million	1000
Grams/liter	pounds/gallon	.00834
Liters	cubic feet	.0353
Milligrams/liter	parts/million	1
Milliliters/gallons	gallons	.0026
Ounces	grams	28.35
Parts/million	grams/liter	.001
Parts/million	pounds/million gallons	8.34
Pounds	grams	453.59
Pounds/gallon	grams/liter	111.83

1 gram = .035 ounce
1 kilogram = 2.2 lbs
1 quintal = 100 kg = 221 lbs

1 metric ton = 1000 kg = 2,205 lbs
1 hectare = 2.5 acres
1 meter = 39.4 inches
1 kilometer = .6 mile